IMPACT OF THREE DIFFERENT FEEDING REGIMENS ON PERFORMANCE, MICROBIOLOGY, SENSORY, AND OBJECTIVE CHARACTERISTICS OF FLORIDA BRANGUS BEEF CATTLE

By

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Two experiments were conducted to evaluate three typical commercially available feeding regimens and their effects on average daily weight gain, prevalence of *E. coli* O157:H7, generic *E. coli*, fecal coliforms, total aerobic bacteria, and parasites in beef cattle. This study also focused on blood chemistry of the animals, the proximate composition of the grass on which animals grazed, animal drinking water, animal feed, the resulting carcass characteristics, pH, objective color characteristics and sensory attributes of steaks collected from the short loin of the carcasses. Sixty Florida Brangus steers, where 30 steers with an average age of 17 months were used for Experiment One, and 30 steers with an average age of 9 months were used in Experiment Two. Steers in both experiments were assigned randomly to one of three feeding regimens: 1) Super 12, a non medicated concentrate, plus bahiagrass, 2) B-80, a medicated concentrate

containing lasalocid, plus bahiagrass, and 3) bahiagrass only (Grazers). Cattle fed Super 12 concentrate had a higher average daily gain (ADG) and reached the target slaughter weight two and three months earlier than cattle fed B-80 and grazer cattle in Experiments One and Two, respectively. Super 12 cattle had significantly higher ($P < 0.05$) carcass weights when compared to grazer cattle in Experiment One, and B–80 and grazer cattle in Experiment Two. No *E. coli* O157:H7 nor *Salmonella* spp. were detected in any of the fecal samples analyzed in both experiments. The cattle fed the two concentrates had significantly lower coccidia parasites in Experiment One but not Experiment Two when compared to grazer cattle. The proximate composition of the grass was similar ($P > 0.05$) for all treatments. Objective color, pH, and Warner Bratzler shear force were similar ($P > 0.05$) for all treatments. In Experiment One sensory panelists detected significantly lower ($P < 0.05$) overall tenderness in steaks from Super 12 fed cattle when compared to grazers. Panelists also detected significantly lower ($P < 0.05$) connective tissue in steaks from the grazer cattle when compared with steaks from Super 12 and B-80 fed cattle. In Experiment Two, panelists detected significantly lower ($P < 0.05$) juiciness in steaks from Super 12 and B-80 fed cattle when compared to steaks from grazer cattle. Data in this study demonstrated that beef cattle grazing bahiagrass and supplemented with Super 12 can be raised in a shorter amount of time and produce steaks acceptable in meat quality and palatability to consumers.

INTRODUCTION

The National Commission on Small Farms, which was designed in 1997 by the U.S. Secretary of Agriculture to examine issues facing small farms, defines a small farm as a farm with less than $250,000 gross receipts annually and on which day-to-day labor and management are provided by the farmer and/or farm family that owns the production or owns, or leases, the productive assets (Hoppe and Banker, 2005). Large farms are defined as farms having sales of $250,000 to $499,999, and very large farms are defined as farms having sales of $500,000 or more. Small farms have been critical to the fabric of American society throughout the nation's history. Today, as historically, the vast majority of all farms in the United States are considered small (90%) but these small farms produced a modest share (28%) of farm output in 2001 (Hoppe and Banker, 2005). Large and very large farms account for only about 7% of farms in the United States but 58% of the value of production in 2001. Owning and operating a small farm represents an avenue to economic independence and entrepreneurial achievement for many Americans from all walks of life. Small farm owners and operators are a diverse group of Americans, including Hispanics, Native Americans, ethnic Europeans, African-Americans, Asians, women, persons with disabilities, and other minorities.

In Florida, the nearly 44,000 commercial farmers are among the most productive in the world, furnishing the nation with a dependable and safe food supply, and providing an

economic base for the state. In 2003, Florida farmers utilized 10.2 million of the state's nearly 35 million acres. Florida ranks No. 9 nationally in the value of farm products with 2002 sales of $6.85 billion. State ranchers and herdsmen rank among the top 28 states in the production of beef, poultry and pork, with livestock and product sales topping $1.2 billion in 2003. Florida employed more than 87,000 farm workers in 2003 and paid them $1.4 billion. In addition, Florida farmers rank third nationally in net farm income with $2.7 billion in 2002 (Mongiovi, 2004).

Production technologies, management systems, research and extension education that are appropriate for small and economically disadvantaged livestock producers are needed to identify and enhance the efficiency, profitability and competitive position of family farms. A major concern of a cattle operation is an effective feeding program. The diversity of programs and methods of raising cattle make this area one that requires factual and practical information. Small and limited income farmers may not have the same resources or capabilities to feed cattle to target weights as a larger producer. Therefore, small and limited income farmers are challenged to provide cost effective and practical approaches to feeding cattle to market weight in order to realize a profit and maintain sustainability. Beef enterprises work well with grain, orchard, vegetable, or other crop operations. Cattle can make efficient use of feed resources that have little alternative use, such as crop residues, marginal cropland, untillable land, or rangeland that cannot produce crops other than grass (Pirelli et al., 2000).

Traditional feeder-cattle enterprises grow weaned calves (450 to 600 pounds) and yearling steers or heifers (550 to 800 pounds) to slaughter weights of 1,100 to 1,400 pounds (Comerford et al., 2001). Many cattle feeders purchase lightweight feeder calves

(350 to 550 pounds), graze them during the spring and summer and then finish them in the feedlot starting in late summer or fall (Comerford et al., 2001). Cattle producers rely on several feeding strategies to bring cattle to market weights. These include extensively feeding pasture only, semi-intensive feeding of pasture and concentrate feeds and intensive feeding of high protein feeds. In many instances, feeds are medicated to increase weight gain and decrease bacteria and gastrointestinal parasite loads. There is increased skepticism for the use of non-therapeutic medications in that the practice is viewed as potentially increasing the resistance by microorganisms and parasites.

The meat and poultry industries are always concerned with the problem of pathogenic bacteria appearing and becoming widespread in fresh and processed meat and poultry products. Since 1996, Food Safety Inspection Service (FSIS), the primary enforcement body of the U.S. for meat and poultry, has required that all plants develop, adopt, and implement a Hazard Analysis Critical Control Points (HACCP) food safety program. This system is designed to ensure the safety of food products by requiring each individual plant that produces meat and poultry, whether fresh or processed, to look at every step in their respective processes, and establish critical control points (CCP's), critical limits (CL's), corrective actions for deviations from the CCP's, monitoring of those CCP's to assure they are under the CL's, and keeping extensive written records. Schmidt (2001) described HACCP as a logical system and preventive approach to food safety designed to identify hazards and/or critical situations and to produce a structured plan to control these situations. The emphasis of HACCP is to base the food safety program on sound scientific data, and to focus on prevention and control of food safety problems at highly specific (and controllable) points in the process chain (Schmidt,

2001). Microbiological contamination of animal carcasses during slaughtering procedures is an undesirable but unavoidable problem in the conversion of live animals to meat for human consumption (Dickson and Anderson, 1991). Although good farming and manufacturing practices discourage harmful bacteria from entering the food supply, they do not guarantee a product that is free of pathogens that could cause food borne illness.

The term "pre-harvest food safety" has been coined to describe attempts to ensure safety of the final product by minimizing or eliminating potential human pathogens and chemical residues from farm animals. Pre-harvest food safety in the food animal area has been recognized for centuries as an important aspect of assuring overall quality and safety of food animal products going into the human food chain (Marion, 2002). Preharvest cattle management significantly impacts public health (Hovde et al., 1999). Cattle transiently harbor *Escherichia coli* O157:H7 in their gastrointestinal tracts, and many human infections result from ingestion of contaminated bovine food products (Kaper and O'Brien, 1998). *E. coli* O157:H7 contamination, which has caused product recalls and plant closures, has an enormous economic impact on the meat industry (Centers for Disease Control, 1997). Human infections with *E. coli* O157:H7 result in hemorrhagic colitis that can progress to hemolytic-uremic syndrome, a life threatening sequela that is the most common cause of acute renal failure in children (Kaper and O'Brien, 1998).

This project work is designed to develop a model program that can be utilized by small livestock producers to enhance the value and safety of livestock products; monitor performance parameters and prevalence of *E. coli* O157:H7, generic *E. coli*, fecal coliforms, total aerobic bacteria, and parasites in livestock when subjected to a

comprehensive feeding and optimized management program; and monitor the effects of the program on dressing percentage, and subjective and objective consumer parameters.

LITERATURE REVIEW

Performance

Performance is the key to success in the cattle business. Good genetics, proper nutrition and top-notch health programs are the all-important ingredients that go into a successful cattle breeding program (Rew, 1998). Improving animal performance, carcass characteristics, and meat quality traits are the main objectives of most research carried out in the beef production area (Sami et al., 2004). Satisfying the consumer's requirement for a consistent product is the major target of beef producers and retailers. Small and limited income farmers are challenged to provide cost effective and practical approaches to feeding cattle to market weight in order to realize a profit and maintain sustainability.

There are two main types of growing and feeding operations–steer/heifer operations and stocker (or backgrounding) operations. In a steer or heifer operation, 500- to 600-pound feeder calves are purchased after weaning at approximately 7 to 10 months of age. They can be fed out and marketed in less than a year from the time of purchase. Thus, the investment on each calf is returned within a comparatively short time. This type of operation may not require much land, but adequate facilities are essential so that animals can be kept comfortable and under control (Pirelli et al., 2000). A stocker or backgrounding operation pastures or feeds calves until they reach 750 to 800 pounds, after which they are sold to a feedlot for finishing. Usually weaned calves or yearlings

are purchased, go on pasture when the grass is ready, and are sold when the pasture season is over. In these calf and yearling enterprises, purchase price and selling price greatly influence profitability (Pirelli et al., 2000).

Cattle producers rely on several feeding strategies to bring cattle to market weight. These include extensively grazing on pasture alone, semi-intensive grazing on pasture with concentrate supplementation, and intensive feeding of high protein feeds. The feeding plan is considered one of the most important factors that affect meat production (Sami et al., 2004). Feed requirements are based on the need for specific amounts of various classes of nutrients. Each nutrient fulfills specific roles in growth, production or metabolism. Nutrient classes are defined by their chemical structure or by their function in metabolism. The classes are energy, protein, minerals, and vitamins.

Energy provides the body with the ability to do work (Hamilton, 1991). In beef cattle rations, energy is usually expressed as % total digestible nutrients (TDN). Maintenance includes growth, lactation, reproduction, movement and feed digestion. Energy is the nutrient required by cattle in the greatest amount. It usually accounts for the largest portion of feed costs (Steen and Kilpatrick, 1995). The primary sources of energy for cattle are cellulose and hemicellulose from roughages, and starches from grains. Fats and oils have a high energy content but usually make up only a small part of the diet.

Protein is one of the main building blocks of the body. It is usually measured as % crude protein (CP) (Kijowski, 2001). It is a major component of muscles, the nervous system and connective tissue. Protein is composed of chains of amino acids. Adequate dietary protein is essential for maintenance, growth, lactation and reproduction. Information about protein sources has changed much over the past 10 years. Words like

"bypass," "escape," or "slowly degraded" have been used to describe some proteins. These terms have the same meaning and refer to a protein source's ability to escape breakdown in the rumen (Stock et al., 1996). Digestible protein entering the rumen is either broken down by the rumen microbes to volatile fatty acids and ammonia or it escapes breakdown and passes "as is" to the small intestine where it is digested and absorbed as amino acids and peptides. This latter protein is called bypass or escape, or sometimes is known as slowly degradable protein (Kijowski, 2001). The extent to which a particular protein source is broken down depends on its rate of rumen digestion. Soybean meal protein is broken down to a greater extent, and less escapes the rumen undigested compared to protein sources like dehydrated alfalfa, blood meal, meat meal or corn gluten meal.

The rumen microbes require a certain amount of nitrogen in the form of ammonia. When feeding sources of protein that are slowly degraded, supplemental urea is used to meet the microbes' nitrogen needs. Although nonprotein nitrogen sources (urea, biuret) are completely broken down in the rumen, they supply only nitrogen to the microbes. They do not supply amino acids, peptides or any carbon chains. The microbes also need carbon chain fragments to form microbial protein. Most of these carbon chains are produced in the digestion of forages or grains. However, certain carbon chains (branched-chain fatty acids) may not be produced in sufficient quantities to provide for maximum microbial protein synthesis. Degradation of feed proteins can supply these limiting branched-chain fatty acids. This protein source is called rumen degradable or rapidly degradable protein.

Protein sources can be divided into four categories: 1) high bypass or slowly degradable protein; 2) intermediate bypass protein; 3) low bypass protein; and 4) rapidly

degradable protein. Examples of high bypass/slowly degradable protein are blood meal, fish meal, corn gluten meal, and dehydrated alfalfa (Stock et al., 1996). Examples of intermediate bypass protein include cottonseed meal and linseed meal. Some examples of low bypass protein are soybean meal, alfalfa (hay, haylage, sun-cured pellets), peanut meal, sunflower meal, safflower meal, feather meal and rape seed (Canola) meal. Rapidly degradable protein sources include casein, whey, steep liquor and distillers solubles (Stock et al., 1996). Animals consuming grain, silage, alfalfa or lush pasture do not need to be supplemented with rumen degradable protein (Stock et al., 1996). Inadequate and excessive intakes of protein have been shown to have significant detrimental effects on the liveweight gain and carcass composition of beef cattle (Lindsay and Davies, 1981; Steen, 1988, 1989).

Various minerals are required for growth, bone formation, reproduction and many other body functions. Those that are required in fairly large amounts are called macrominerals (Hamilton, 1991; Romans et al., 1994). They include sodium (salt), calcium, phosphorous, magnesium and potassium. Those that are required in very small amounts (micro or trace minerals) include iodine, copper, zinc, sulphur and selenium. Adding supplementary minerals to the ration is usually required to ensure that the proper amounts of these elements are available to the animal. The type of supplementary mineral mix required is determined by the feeds in the ration and the animal's requirements (Hamilton, 1991).

Vitamins are biological compounds which are active in extremely small amounts. Vitamins of concern in beef cattle nutrition include Vitamin A, Vitamin D and Vitamin E. They are usually reported in International Units (IU's) (Hamilton, 1991; Romans et al.,

1994). Vitamin needs of beef cattle are largely confined to A, D, and E, because bacteria in the rumen of cattle are considered to have the ability to synthesize vitamin K and the B vitamins in sufficient quantities to meet the animal's requirement (Sewell, 1993). Vitamin K is essential in the liver for production of prothrombin. Low levels of prothrombin in the blood lengthen blood clotting time and cause internal bleeding. Some metabolic functions of vitamin A are not yet known. A chief role is maintenance of epithelial tissue (skin and lining of respiratory, digestive and reproductive tract) in a healthy condition. Vitamin A is essential for proper kidney function and normal development of bones, teeth and nerve tissue (Sewell, 1993). Vitamin D increases the absorption from the digestive tract and metabolic use of calcium and phosphorus. It helps regulate blood calcium levels and the conversion of inorganic to organic phosphorus. Vitamin D aids in the formation of sound bones and teeth (Sewell, 1993). Its principal role may be as a chemical antioxidant to reduce the destruction of other vitamins and essential fatty acids both in the digestive tract and after their absorption. Stiff-lamb disease and white-muscle disease in calves have been prevented and cured by use of vitamin E (Sewell, 1993).

Fresh forage is a good source of Vitamins A, D and E. Vitamin content of well preserved hay is initially high, but declines over time. Silages usually contain low levels of vitamins because the fermentation process destroys most of the vitamins. Grains usually contain relatively low amounts of these vitamins (Hamilton, 1991; Romans et al., 1994).

Pasture and Forages

The world's most abundant renewable sources of energy are pastures and forages. Swine, poultry, and humans are unable to utilize forages to any great extent because monogastrics lack the enzymes or bacteria needed to degrade fibrous compounds. Fortunately, ruminant animals can utilize this energy through their symbiotic relationship with fiber-fermenting microorganisms in the rumen (Cecava, 1995).

Cattle grazing is an efficient way to produce food for human use on land where crops for human consumption cannot be produced. In the U.S., land area that is used for grazing animals is more than twice the size of land area that can be used for producing food. The use of land to graze animals more than doubles the land area in the U.S. that can be used to produce food. The number of acres needed for each cow depends on the level of forage production, as well as the cattle and their management. The level of forage production varies with species, soil fertility, moisture, temperature, season, and other related factors (Aerts and Nesheim 2002).

Grasses are the backbone of the Florida livestock industry. Different grasses are used for different purposes depending on season of year (warm or cool season), soil conditions (dry or wet), age of livestock utilizing the forage (mature cattle or weaned calves), management methods used (continuous or rotational grazing), and fertilization program (Mislevy, 2002). Some forages can also be grown for hay, while others are suitable only for grazing. Several forages that grow in south Florida cannot be grown in north Florida because they lack sufficient cold tolerance. Some forages can only be grown on well-drained soils while others are adapted to very moist soils (Aerts and Neseim, 2002).

Pastures and forages can be classified into two different categories that designate their general life expectancy. These classifications are permanent (perennials) and temporary pastures (annuals). Permanent pasture is a type of pasture that lives for many years. This type of pasture is usually found on land that cannot be used for cultivated crops, largely because of topography or moisture. With minimal care, such pastures can last indefinitely. Most farms have at least some such land which is fit only for permanent pasture (Cecava, 1995). Temporary pastures are pastures that are seeded for use for very short periods of time. They are provided when regular permanent or rotational grazing is not available. Examples include, sudan grass or sudex seeded in the spring for summer grazing, or oats and rape seeded for spring and summer grazing. Rye may often be seeded following bean or corn harvest for fall and winter grazing (Cecava, 1995).

The success of a beef cattle operation is tied directly to the amount and quality of forage, whether pasture or hay, available to the beef animals. As a general rule, readily available pasture of high quality is the cheapest source of feed nutrients (Aerts and Nesheim, 2002). Selection of pasture species for beef cattle depends on three major factors: temperature, soil moisture, and soil fertility. Selection of pasture species in Florida must focus primarily on temperature, due to the wide-ranging climate. South Florida has a climate similar to subtropical regions, while north Florida has subtropical summers but temperate winters (Aerts and Nesheim, 2002).

One method of categorizing pasture crops is to divide them into grasses and legumes. The grasses include, bahiagrass, bermudagrass, bluegrass, bromegrass, timothy, fescue, and sorghums. The legumes include, alfalfa, bur clover, red clover, alsike clover, white clover, birdsfoot trefoil, and vetches. Warm season perennial grasses, are the

foundation of pastures in Florida. Bahiagrass is predominantly used. It can be established from seed and is widely adapted, very dependable, persistent, and easy to manage (Aerts and Nesheim, 2002).

Generally, crude protein (CP) content of a forage is positively correlated with quality. In general, high-protein forages are considered high-quality forages. If a high-protein forage is fed, less supplemental protein will be needed. This usually reduces feed costs since most protein supplements are purchased. High-protein forages generally are more digestible and provide more energy per pound than low-protein forages (Aerts and Nesheim, 2002).

Fiber content of forages is inversely related to quality. Fiber can be measured many ways, but the single best method for comparing different forages is neutral detergent fiber (NDF) (Weiss et al., 1999). Acid detergent fiber (ADF) is determined frequently and is useful in comparing and estimating forage quality within forage species, however it is not a good measurement to compare quality among different forage species. Plant fiber is composed largely of cellulose and hemicellulose. The amount of cellulose is relatively constant among forage species, but the amount of hemicellulose differs greatly between grasses and legumes. Cellulose is the primary constituent of ADF, but NDF contains both cellulose and hemicellulose. Therefore, grasses and legumes may have similar ADF values, but NDF values will almost always be substantially higher for grasses. Fiber content and energy content are closely related since almost all researchers use fiber (either ADF or NDF) to estimate available energy. Concentration of fiber is negatively related to quality because forages with high concentrations of fiber contain less available energy and are consumed in lesser amounts by cows than are forages with low amounts of fiber.

Bahiagrass

Bahiagrass (*Paspalum notatum*), a warm-season perennial, is grown throughout Florida and in the Coastal Plain and Gulf Coast regions of the southern United States. At least 70 percent of Florida pasture acreage is bahiagrass (Pate, 1992). In Florida, bahiagrass is used on more land area than any other single pasture species, covering an estimated 2.5 million acres (Chambliss, 2002; Arthington, 2000). Most of this acreage is used for grazing with some hay, sod, and seed harvested from pastures. Bahiagrass is adapted to climatic conditions throughout Florida and can be grown on upland well-drained sands as well as the moist, poorly-drained flatwood soils of peninsular Florida (Chambliss, 2002).

Bahiagrass is a warm-season grass that produces more grazing in summer than winter. Due to the longer growing season, forage growth is more evenly distributed throughout the year in southern Florida than in northern Florida. In southern Florida, growth of bahiagrass pastures slows in October, and many pastures have very little forage after mid-December until the grass starts growing again in early March. In northern Florida, bahiagrass pastures are productive from April to November (Chambliss, 2002).

A major advantage of bahiagrass is persistence, even with little or no management. It grows well with limited amounts of fertilizer, usually 50 pounds of nitrogen (N)/acre usually applied in the spring. This is an important practice to improve the amount and quality of grazing at a critical time of year. For cows coming off winter pastures and onto bahiagrass from March to May (a 90-day breeding season), it helps provide needed nutrition to get lactating cows into a weight-gaining condition to increase their chances of rebreeding. For cows bred from December to February, it provides nutrition to improve

lactating ability of cows and, hence, bigger calves. Whatever the situation, the results of spring fertilization of bahiagrass are dependent on rainfall, which is often very little at this time. Day length and temperature are not the limiting factors that they are in winter.

Crude protein in –fertilized bahiagrass in April is two to three percentage units greater than that found in unfertilized grass (12 to 15 percent for fertilized versus nine to 12 percent for unfertilized grass) (Kalmbacher and Wade, 2003). Bahia has moderate quality for most of the year, having 8 to 10 percent crude protein and about 50 percent TDN, with little or no fertilizer. The lower the rainfall, the higher the crude protein concentration in leaves because yields are lower and protein is more concentrated. By June the difference in crude protein concentration between fertilized and unfertilized grass is minimal (both will be eight to 10 percent). Across the April-to-June period, crude protein in the total mass of grass produced during this period averages one to two percentage units greater with N fertilization. Total digestible nutrients (TDN) in bahiagrass will be increased by N fertilizer applied in March, but only by one to two percentage units (Kalmbacher and Wade, 2003). It may be the best grass for small ranches where grazing management is difficult and having a dependable grass is most important (Pate, 1992).

Bahiagrass is popular with Florida ranchers because it: 1) tolerates a wider range of soil conditions than other improved grasses; 2) has the ability to produce moderate yields on soils of very low fertility; 3) is easily established from seed; 4) withstands close grazing; and 5) is relatively free from damaging insects (except for mole crickets) and diseases (Chambliss, 2002).

One major disadvantage of bahiagrass is that it will never obtain a consistently high quality, regardless of management or fertilization practices. It is not a good grass as the only forage for young cattle. Its quality particularly TDN, is low in the winter and supplementation is needed for any class of cattle grazing bahiagrass during this period (Pate, 1992). Other disadvantages of bahiagrass are that it is susceptible to mole crickets. Bahiagrass is used mainly for beef cattle pastures. If it is fertilized, rotational grazing can be sustained from approximately mid-March to mid-November. However in Northern Florida, this period is slightly reduced (Chambliss, 2002). The quality of bahiagrass forage is adequate for mature beef cattle, but weaned calves or stocker yearlings make relatively low daily gains, especially from July through September (Chambliss, 2002).

Bermudagrass

Bermudagrass has excellent agronomic characteristics making it a popular perennial forage grown in much of the southeastern U.S., including Florida. The grass has high-yielding ability, high-drought resistance, and sufficiently tolerates highly-acidic soils (Staples, 1995). There are several different hybrids of bermudagrass. Coastal, Alicia, Callie, Tifton 44, Tifton 78, and Tifton 85 are examples. Coastal was the first major hybrid developed and occupies more acreage than all other hybrids combined. The Alicia hybrid, has the lowest quality of the group. It is susceptible to rust disease. Rust diseases are found throughout the U.S. on most species of grasses (Duble, 2004). Alicia is lower yielding than Coastal, and is usually used as a last choice for planting (Staples, 1995). Callie is good quality, being superior to the Coastal hybrid, but it is susceptible to rust in the spring, which can reduce yield and quality, depending upon the extent of the rust infestation. Tifton 44 is the most winter-hardy of the group, but its forage quality is

lower than other newly developed hybrids. Utley et al., (1978), conducted a study comparing Tifton 44 and Coastal bermudagrass as pastures and as harvested forages. Utley et al. (1978) reported that the average daily gain of steers grazing Tifton 44 bermudagrass was 19% greater than steers grazing on Coastal pastures. When pellets made from Tifton 44 and Coastal forage of comparable chronological age were fed, steers given the Tifton 44 pellets gained 19% more on 16% less fed. Tifton 78 has been shown to produce the highest quality forage but establishment has been a problem for many producers (Staples, 1995). Tifton 85 bermudagrass is the fastest growing, tallest, and largest stem hybrid of the group. A study conducted by Hill et al. (1993) showed that when compared to Tifton 78 in a 3-year grazing study using steers, Tifton 85 supported equal body weight gains and more grazing days per acre.

Bluegrass

Characterized by Kentucky bluegrass, these non-legumes are common in the northeastern quarter of the United States, where there are cooler conditions with adequate rainfall. Bluegrass is adapted to better-drained loams of limestone origin, such as those in Virginia and Kentucky. One of the disadvantages to this pasture grass is the marked periodicity in growth and development: greatly reduced production occurs from mid-July through August (Cecava, 1995). It is well adapted to mixtures with legumes, especially the white clovers and birdsfoot trefoil, but it is too competitive with alfalfa and red clover. Following its dormancy period in late summer, it responds to Fall rains and produces well in September and October. Unpastured bluegrass that is allowed to grow and fall over is a most excellent forage crop for beef cattle in the late fall months (Cecava, 1995).

Bromegrass

These grasses are adapted to cool climates or to regions in which cool seasons prevail for a portion of the season. The Greek derivative *Bromus* signifies oats and thus the name oats grass often has been applied. There are at least 60 varieties of bromegrass; the most common is smooth bromegrass. It is fairly resistant to drought, but in severe drought it becomes dormant much the same as other grasses. Smooth brome is used both alone and in mixtures with other grasses and legumes. In mixtures with legumes, the first cutting often goes for hay, followed then by grazing. Bromegrass is one of the most palatable of the grasses and maintains its palatability and nutritive value at much later stages of growth than most grasses, except perhaps bluegrass (Cecava, 1995).

Timothy

Timothy is adapted to a cool and humid climate, and thus it is restricted primarily to the northeastern portion of the United States. It is grown primarily for hay but is generally included in pasture seeding mixtures, especially with clover. Such mixtures are generally harvested in the first growth of the year for hay, at the time the timothy heads bloom. Subsequently it can be grazed as a pasture mixture. Young, succulent timothy is often relished more than bluegrass by livestock. Timothy is gradually crowded out of permanent pasture by bluegrass (Perry and Cecava, 1995).

Fescue

The fescue group has a wide distribution but the greatest concentration of growth is in the southeastern United States and along the coasts of Oregon and Washington. In the southeast, fescue is especially important as a winter pasture crop and does not persist as well in the hot summer environment. Fescue establishes one of the strongest sods which

is thus resistant to breakthroughs from grazing traffic. Its winter growth habits make it important in a grazing program designed for year-round use (Cecava, 1995). Fescue pastures can tolerate more grazing abuse than any other pasture sod. Heavily overgrazed pastures seem to come back with excellent growth after cattle are removed (Cecava, 1995).

A disadvantage of feeding fescue is that at certain phases of their growth the fescues become rather unpalatable and cattle will not eat them unless forced (Cecava, 1995). This is caused by an endophyte fungus (*Acremonium coenophialum*) which infects the fescue plant. The fungus has no adverse effects on the plant itself but can cause toxicity in animals grazing infected pastures. There is also the matter of "fescue foot". This is a condition in which animals grazing fescue tend to become lame. They eventually develop a deformed hoof which may slough off. Establishment of 15-30% legumes in a fescue pasture appears to counteract the periodic toxic aspects of fescue pasture for beef cattle (Perry and Cecava, 1995).

Sorghums

Sorghums for pasture are perhaps best typified by sudan grass and hybrids thereof. The sorghum plants are resistant to drought and thus, they are grown primarily in the southern Great Plains area. Sudan grass grows most rapidly in hotter weather when most other pasture crops are dormant (Cecava, 1995). Cattle relish sudan grass. Sudan grass is especially adapted to rotation grazing; while one plot is recovering from having been grazed, the other is being grazed into the ground. Sudan grass stores energy in its roots, thus there is no danger to the plant in grazing it down to the ground (Cecava, 1995).

A disadvantage to grazing sudan grass is there is always the potential danger of prussic acid poisoning for cattle. The most critical times for this are in the early stages (two- and three-leaf stages) or immediately after the plants have been frosted or frozen. Mature sudan grass or that which has been cut for hay or silage has no danger for poisoning cattle (Cecava, 1995).

Alfalfa

Alfalfa, or lucerne, as it is called in many parts of Europe, is well adapted to a wide range of climatic and soil conditions. It responds to fertilization and water along with good cultural practices, including inoculation with nitrogen-fixing bacteria. It is one of the most important forage plants in the United States because it has the highest feeding value of commonly grown forage crops. It produces more protein than that of clover and many times that produced by the nonlegumes (Perry and Cecava, 1995). Alfalfa, if harvested in the late bud stage of maturity, can contain 20 to 25% CP on a dry matter basis (DM basis). If it is harvested in late maturity it can contain 10 to 14% CP (DM basis). Grasses, if fertilized properly and harvested in the vegetative stage of maturity, can have more than 20% CP. An exception to this general relationship is corn silage, which is low in CP but is a high-quality forage because of its energy content (Weiss et al., 1999). High-quality alfalfa will contain 35 to 40% NDF (25 to 30% ADF), and high-quality grasses will contain 55 to 60% NDF (30 to 35% ADF). Low-quality grasses can contain 70 to 80% NDF (Weiss et al., 1999).

Alfalfa is not used commonly as the sole pasture crop for beef cattle because of its bloat-causing effect. It is much more satisfactory as a pasture crop for beef cattle when it is grown in a mixture with nonlegumes, such as bromegrass or orchardgrass, or even

bluegrass. Alfalfa can be prone to insect infestation and a variety of diseases associated with bacterial infections so it is often difficult to maintain a stand of alfalfa (Perry and Cecava, 1995).

Bur Clover/Spotted Bur Clover

These are relatives of alfalfa. They are weak stemmed plants resembling clovers. California bur clover contributes to the range pastures of the California and Arizona foothills. In the southeastern states, spotted bur clover is the primary species. All bur clovers are unable to stand the rigors of winter and thus are restricted to more temperate climates (Perry and Cecava, 1995). In the western states, bur clover comes up as a "volunteer" in range pastures whereas in the southern states spotted bur clover must be seeded. However, once seeded, stand life is indefinite (Perry and Cecava, 1995).

Red Clover

Red clover grows abundantly in the midwest, as well as in the entire northeastern quarter of the United States. Furthermore, it grows well as a winter annual in the southeastern United States, and under irrigation in the six or seven far western states. Red clover is seldom used as the sole pasture crop but rather is grown in mixtures with grasses (Perry and Cecava, 1995).

Alsike Clover

Alsike clover is a perennial which contributes to cattle pasture mixtures. Because of its adaptation to wet soils, Alsike is good for establishing pasture sod on wet natural meadows or where irrigation is used. It may persist in bottomlands along creeks or rivers where alfalfa and red clover are unable to survive. It is well adapted to cool climates. It

can tolerate greater soil acidity than clover or alfalfa, but nevertheless responds to limestone applications (Perry and Cecava, 1995).

White Clover

These are perennials and are grown widely throughout the world. This group is one of the most nutritious and palatable of all the legumes. The white clovers are usually grown in association with other legumes or with grass, or with complex mixes of both. It also occurs as weeds of lawns, turfgrass, landscapes and orchards. The white clovers usually appear as volunteers, especially in the cooler northern pastures (Cecava, 1995). White clover pasture is not very desirable as a horse pasture because it causes excessive salivation or "slobbering" of horses (Perry and Cecava, 1995).

Birdsfoot Trefoil

Essentially grown in the northeastern quarter of the United States and also along a narrow strip of the west coast, birdsfoot trefoil has not had a wide acceptance as a pasture legume because of the extremely slow development of its seedlings; in mixtures with clovers and grasses, birdsfoot is not able to compete (Cecava, 1995). It has some resemblance to alfalfa. However, no cases of cattle bloat are known to have occurred on birdsfoot trefoil (Cecava, 1995). It has a wide soil tolerance to fertility and acidity. It is a perennial which reseeds itself, even when grazed closely. It is especially compatible with Kentucky bluegrass, and may stay in existence and in balance for many years (Perry and Cecava, 1995).

Vetches

The vetches are most common in the southeastern quarter of the United States. Some 150 species are known, about 25 of which are native in the United States. There

are several varieties of vetch including hairy, madison, common, Hungarian, narrowleaf, purple, and bard. They are especially well adapted as cover crops for land exposed in highway construction because of their matting characteristic. They are usually considered winter annuals, reseeding themselves each year. During the winter period of the year, land in the southern states is not occupied with cash crops such as cotton or peanuts, and thus the vetches are excellent crops at that time. All vetches are edible and palatable to cattle but only those with hard seed and good seeding habits are recommended for use in permanent pastures. Vetches may become troublesome weeds in grain fields but are readily controlled with herbicides. These include hairy and smooth vetches (Perry and Cecava, 1995).

Concentrates and Supplements

Cattle have the capacity to utilize tremendous quantities of roughage because of the anaerobic microorganisms found in the rumen. Cattle subsisted primarily on forages and roughages as sources of energy and other nutrients for centuries. However, man domesticated cattle and introduced concentrated energy and protein feedstuffs into the ruminant diet. Concentrate feeding was and continues to be attractive from an economic standpoint. Cereal grains and animal and plant proteins can often be used to supply energy and protein at lower cost per nutrient input compared with forages (Cecava, 1995).

Supplements are often fed to heifers and steers after weaning until winter pasture is ready for grazing. Grain supplements such as corn will improve gains of calves grazing residual pasture or fed hay. Several by-product feeds are also available in Florida and often are lower-cost sources of energy and other nutrients than corn and other grains.

Feeds such as molasses, whole cottonseed, citrus pulp, soybean hulls, wheat midds and hominy are available in many areas of Florida (Kunkle et al., 2004).

The major source of energy concentrates for cattle is cereal grains, primarily corn, grain sorghum, barley, oats, and wheat. The major sources of plant protein concentrates include the oilseed meals (i.e., soybean, cottonseed, and linseed) and by-products of cereal grain processing, such as corn gluten meal, corn gluten feed, distiller's grains, and brewer's grains. The major sources of animal protein concentrates are by-products of the animal processing industry. These include bloodmeal, meat and bone meal, fishmeal, and poultry feathermeal.

Quantitatively, corn grain is the most important cereal concentrate fed to livestock in the United States. As would be expected, the majority of grain consumption by beef cattle occurs in the feedlot. Almost 90% of all cattle on feed are located in 13 states found primarily in the Midwest or high plains regions of the country, where grain is plentiful (Cecava, 1995).

All of the cereal grains are high in starch and low in fiber. They are rich in energy and generally quite palatable. The highest concentrations of digestible energy are found in corn, grain sorghum, and wheat. Lower energy concentrations are found in barley and oats. Generally, the balance of amino acids is poor for the cereal grains. Notably, grains tend to be deficient in lysine and tryptophan. Corn is especially low in total protein, averaging 7.8 to 9.0% protein on a dry matter basis whereas barely and grain sorghum may contain 12% protein or greater. Cereal grains are extremely low in calcium but almost adequate in phosphorous relative to the needs of growing cattle (Cecava, 1995).

Lipids also represent a source of energy used in beef cattle diets. The rendering industry is a source of tallow and lard (grease) commonly fed to growing and finishing cattle. Substantial amounts of lipid from vegetable sources, such as soybean oil, are also used (Loest et al., 2001; Cecava, 1995).

Whole Cottonseed

Whole cottonseed is a by-product of cotton production. Whole cottonseed can be fed to ruminants or processed for its oil content, and an increasing proportion has been fed in recent years. Whole cottonseed is high in TDN (94%) and crude protein (23%) and is a good feed for cattle (Kunkle et al., 2004). Cottonseed is light, with a weight of 9 to 11 kg/0.03 m^3 (20 to 25 lb/ft^3). It is usually transported in dump trailers or trucks with a bottom conveyor. It can also be transported and stored in peanut drying wagons. Cottonseed must be dry or it will mold during storage. Cottonseed does not need to be processed and can be mixed in diets or fed in feedbunks or on a clean sod. At first offering, whole seed may need to be mixed with other ingredients, but after adaptation cattle will usually consume it readily. Feeding cottonseed at a level to meet the supplemental protein needs of growing cattle and beef cows is common (Kunkle et al., 2004). Cottonseed can also be fed as an energy supplement depending upon economic feasibility (Kunkle et al., 2004).

Feeding cottonseed to beef cattle does have disadvantages as well. Due to the high fat content (18%) and gossypol, a toxic pigment obtained from cottonseed oil, whole cottonseed should be limited to roughly 25% of the total dry matter intake of beef cattle (Kunkle et al., 2004).

Cottonseed Meal

Cottonseed meal is a high protein by-product from the extraction of oil from whole cottonseed. Cottonseed meal is palatable and commonly is used in cattle rations in the southern and western U.S. (Kunkle et al., 2004). Cottonseed meal is used as a protein supplement and can replace all of the soybean meal in the ration. Cottonseed meal contains gossypol, which is a toxic pigment obtained from cottonseed oil and is detoxified by heating. Although cottonseed meal contains gossypol, under typical conditions where protein supplement is given, even high-producing cows will not consume enough cottonseed meal to suffer from gossypoltoxicity (Kunkle et al., 2004). Cottonseed meal contains approximately 41.5% crude protein, 1.5% fat, 12.5% crude fiber, and has a 70% TDN (Cecava, 1995). Brown and Pate (1997) reported Brahman crossbred yearling steers fed ammoniated hay plus a liquid cane molasses based supplement containing cottonseed meal and urea, or feather meal and urea gained more weight and were more efficient than steers supplemented with urea only.

Citrus Pulp

Citrus pulp is a by-product of the orange- and grapefruit-processing industries, with over 500,000 tons produced annually in Florida. Citrus pulp has a 79% TDN and 8% crude protein concentration, making it a good energy supplement for cattle. Most citrus pulp is dried, and much of the supply was exported to Europe during the 1980s. Supplies are available during the citrus-processing season with prices fluctuating with the international market. Wet citrus pulp is available seasonally during periods of heavy harvest and may be an economical supplement for cattle within 30 miles of the processing plant (Kunkle et al., 2004).

Most dried citrus pulp is ground and pelleted, which nearly doubles its bulk density and improves its handling characteristics. It is sensitive to moisture and needs to be dry when stored. Pelleted citrus pulp will usually flow in storage bins and self feeders and can be mixed with other feed ingredients. Citrus pulp is very palatable to cattle and will improve the intake of some rations. Wet citrus pulp (15 to 20% dry matter) is acid and can be stored for short periods. Most wet citrus pulp is fed by dumping piles in pastures and allowing cattle to consume it, which results in some spoilage and wasted pulp (Kunkle et al., 2004).

Molasses

Another supplement that can be used for beef cattle is molasses. Molasses is a by-product of the sugar, wood and citrus processing industries. Cane and beet molasses are by-products of sugar manufacturing from sugar cane and sugar beets, respectively, whereas citrus molasses is produced from the juice of citrus waste. Wood molasses is produced during paper manufacturing (Cecava, 1995). Cane molasses is extremely palatable to beef cattle, and is often included for its dust-settling effect and for the pleasant aroma it imparts to feeds. Cane molasses can be offered on a free-choice basis or it may be incorporated into a portion of the ration, as in the protein supplement, or into the total ration. When molasses is included in dry diets, it is usually restricted to less than 10 to 15% of the diet on a dry matter basis because diets containing higher amounts are difficult to handle and may cause digestive disturbances (Cecava, 1995).

Soybean Hulls

The soybean hull is the seed coat removed during oil extraction. It is usually toasted and ground after removal and may be added back to the meal. Soybean meal with 48%

crude protein does not have the hulls added back after processing, and 44% soybean meal contains the hulls. Soybean hulls are high in fiber that is highly digestible by ruminants. Soybean hulls contain 77% TDN, 12% crude protein and 14% starch. The low starch concentration results in a lower rate of fermentation and reduces problems with acidosis (Kunkle et al., 2004).

Unpelleted soybean hulls are light and bulky with a weight of 9 kg/0.03 m^3 (20 lb/ft^3). Pelleted soybean hulls have a higher bulk density. They are usually stored in flat-bed storage and loaded with a front-end-loader. They are very palatable to cattle and are a good feed for newly weaned calves. The protein, calcium and phosphorus is usually adequate and nearly balanced, making soybean hulls a commodity that can be fed without mixing with other feeds. They have also been used to supplement bulls since soybean hulls are palatable and their low starch concentration reduces the chance of acidosis and founder. When used as a supplement with forage, soybean hulls have less of a depressing effect on forage intake and digestibility, and usually result in better cattle gains than cattle fed similar amounts of TDN from grains (Kunkle et al., 2004).

Cotton Gin Trash

Cotton gin trash contains mostly cotton lint with some pieces of stems, immature seeds, and other cotton plant parts harvested with the cotton. It is a waste product at cotton gins and often is hauled to landfills. Typically cotton gin trash has an energy concentration similar to mature bahiagrass hay and protein is typically 10% or higher. It is best suited as a feed source for mature dry beef cows and is usually available for the cost of hauling from the cotton gin. Cotton gin trash is bulky and often hauled in trucks with live bottoms and unloaded in the fields where it is fed to cattle. It smells good and is very

palatable to cattle. Cotton gin trash is limited in energy, and additional supplements may be needed to avoid body condition loss and improve cattle performance (Kunkle et al., 2004).

Urea

Urea is a non-protein nitrogen (NPN) compound. Urea supplies part of the protein equivalent in many of the commercial supplements formulated for beef cattle today. When soybean meal and other plant proteins are high in price, more urea is used to replace plant protein in the ration of beef cattle and sheep (Sewell, 2006). The simple urea compound contains 46.7 percent nitrogen. Most of the urea used in livestock feeds has 45 percent nitrogen, but some has 42 percent (Sewell, 2006). Feed grades of urea have less nitrogen than the pure compound because the particles of urea are coated with clay or treated with formaldehyde or other material to prevent caking and lumping. Cattle, sheep and other ruminants can use urea to replace part of the protein in their diet because of the host of microorganisms (bacteria and protozoa) present in their rumen. In their multiplication and growth, rumen microorganisms use the ammonia released from the breakdown of protein and non-protein nitrogen compounds (urea, etc.) to manufacture microbial protein. The bacteria and protozoa produced in the rumen pass further down the digestive tract and are digested, making the proteins from their cells available to the host animal (Sewell, 2006).

Shain et al. (1998) reported that supplementing crossbred yearling steers with 0.88, 1.34, and 1.96% urea had no effect on dry matter intake, average daily gain, or feed efficiency. However, steers fed diets supplemented with urea were 5.4% more efficient and gained 6.6% faster than steers receiving no supplemental urea (Shain et al., 1998).

Feed Additives

The proper nutrition of beef cattle is a key component of a successful production system. Feed usually accounts for the single largest input cost associated with beef cattle production (Hamilton, 1991). Increased demand for leaner beef and consumer resistance to beef with a high fat content have necessitated interest in the effects of feeding strategy on the carcass composition of beef cattle (Steen and Kilpatrick, 1995).

One management strategy for reducing feed costs and improving gain is the use of feed additives. Their primary effects are to improve feed efficiency and/or daily gain. Some feed additives have secondary benefits which include reducing the incidence of acidosis, coccidiosis, and grain bloat, while others suppress estrus, reduce liver abscesses, or control foot rot problems.

Each feed additive has its own characteristics and feeding limitations. Some are approved to be fed in combination with others. Using the proper level of feed additives is very important because excessive levels will decrease animal performance, especially with cattle on low-quality roughages.

Antibiotics

One type of feed additive is antibiotics. In domestic animals antimicrobial agents are used for three major purposes: therapy to treat an identified bacterial infection, prevention of bacterial infections in animals at risk, or as feed additives to enhance performance (van den Bogaard and Stobberingh, 1999). Veterinary antibiotic therapy involves treatment of an individual animal or a group of sick animals with one or more antibiotics during a defined period of time, and in most Western countries, only upon prescription from a veterinarian. Similarly, antibiotics can be prescribed by a veterinarian

for a defined period of time to prevent the spread of an existing infection in a herd. In the situations when antimicrobials are used for therapy or for prevention of disease in a group of animals, antibiotics are mostly dissolved in the drinking water or milk, or mixed in the feed. This is called group or mass medication (van den Bogaard and Stobberingh, 1999). Apart from veterinary use, antibiotics are added to the feed of animals used as a food source (i.e. "food animals") for humans (e.g. pigs, poultry and cattle), to enhance their performance and increase growth (van den Bogaard and Stobberingh, 1999; Schroeder et al., 2002). In this situation they are considered antimicrobial growth promoters (AGP). The term growth promoter is used for feed additives, other than dietary nutrients, which increase growth rate and/or improve feed efficiency in healthy animals fed a balanced diet (van den Bogaard and Stobberingh, 1999). Antimicrobial growth promoters are more effective in young than in older animals. The general opinion is that the observed growth and feed efficiency responses to the use of AGP are lower under optimal hygienic and animal husbandry conditions compared with poorer environments (Rosen, 1995; van den Bogaard and Stobberingh, 1999). Despite the fact that AGP are not intended for and not registered for prevention of bacterial diseases, a part of their positive effect is most likely caused by prevention or suppression of bacterial infections. This might be an explanation of why they are more effective in young animals and when used under suboptimal conditions. Other names for AGP are antimicrobial performance enhancers, antimicrobial feed additives, feed savers, digestion enhancers or intestinal flora modulators (van den Bogaard and Stobberingh, 1999).

In the 1950's, microbiologists began to detect bacteria that were resistant to antibiotics, and these resistances were spread from one bacterium to another on extra-

chromosomal elements called plasmids (Russell and Houlihan, 2003). Resistance to antimicrobial drugs can arise either from new mutations in the bacterial genome or through the acquisition of genes coding for resistance. These genetic changes alter the defensive functions of the bacteria by changing the target of the drug, by detoxifying or ejecting the antibiotic, or by routing metabolic pathways around the disrupted point (Witte, 1998). Antimicrobial-resistant bacteria from food animals may colonize the human population via the food chain, contact through occupational exposure, or waste runoff from animal production facilities (Witte, 1998; van den Bogaard and Stobberingh, 1999; Schroeder et al., 2002). Food animals, in particular mature cattle, which may be asymptomatic carriers of *E. coli* O157:H7, when exposed to antimicrobial agents in the animal production environment, may serve as a reservoir of antimicrobial resistant bacteria (Schroeder et al., 2002).

Antibiotics have been used to improve gain and feed efficiency of cattle. Antibiotics are added to feed to minimize secondary bacterial infections and to control liver abscesses. Some of the antibiotics available include chlortetracycline, oxytetracycline, bacitracin, and tylosin.

Beef cattle are commonly fed a class of antibiotics known as ionophores. Ionophores alter rumen fermentation characteristics, as well as inhibit the growth of specific rumen microorganisms. The result is improved feed efficiency at the same or higher level of gain compared to a diet without ionophores. Several authors have reported that ionophores can increase feed efficiency by as much as 10% (Goodrich et al., 1984; Russell and Strobel, 1989). Ionophores alter rumen fermentation in three major ways. First an improvement in the efficiency of energy metabolism occurs by changing

the types of volatile fatty acids produced in the rumen thus decreasing energy lost during fermentation of the feed. Improved animal performance results from increased energy retention during fermentation in the rumen. Second, ionophores decrease the breakdown of feed protein and may also decrease microbial protein synthesis. This has minimal effects on the performance of cattle on high-grain diets, but may have important implications with growing cattle fed high-roughage diets. Third, ionophores may reduce the incidence of acidosis, grain bloat, and coccidiosis. Reducing these stresses should result in improved animal performance (Goodrich et al., 1984; Russell and Strobel, 1989). With high-grain diets, ionophores generally decrease feed intake, improve feed conversion, maintain or increase daily gain, and do not affect carcass characteristics. When cattle in confinement (feedlot) are fed diets containing large proportions of roughage, ionophores improve daily gain and feed conversion. Feed intake of animals fed high-roughage diets do not change if the proper level of ionophore is fed (Goodrich et al., 1984; Russell and Strobel, 1989).

Important ionophores include monensin, lasalocid, salinomycin, and narasin. At present, monensin (Rumensin^{Tm}) and lasalocid (Bovatec^{Tm}) are the only ionophores approved to be fed to beef cattle. The ionophores Rumensin^{Tm} and Bovatec^{Tm} are probably the most familiar ionophores for producers because they have been on the market for a relatively long time.

Ionophores are lipophilic compounds that are toxic to many bacteria, protozoa, fungi, and higher organisms (Russell and Strobel, 1989). Their mode of action is their ability to penetrate into biological membranes and subsequently alter the flux of ions from and into the cell. They attach to the lipid bilayer of the cell membrane of ruminal

gram-positive bacteria and protozoa (Chow et al., 1994; Ipharraguerre and Clark, 2003). Once at the membrane interface, they interfere with the flux of ions either by forming cyclic ion-ionophore complexes that function as ion-selective mobile carriers (e.g. monensin and lasalocid) (Bergen and Bates, 1984; Russell and Strobel, 1989) or by creating pores that promote a less specific influx and efflux of ions (e.g. gramicidin) (Russell and Strobel, 1989). More specifically, they facilitate the net exchange of intracellular K^+ for extracelluar protons and Na^+ across the membrane. This forces gram positive microorganisms to expel protons and Na^+ at the expense of adenosine triphosphate (ATP), causing a depletion in the energy reserve, impaired cell division and likely death of the microorganism (Russell and Strobel, 1989). The net effect is a change in the microbial ecosystem of the rumen favoring mostly gram negative microorganisms that are not sensitive to ionophores (Russell and Strobel, 1989). The effect of ionophores on the rumen volatile fatty acid profile is an increased proportion of propionate to acetate in the rumen. There is also a depression in methane (CH_4) production.

Ionophores are fed to approximately 90% of all feedlot cattle in the U.S. They are particularly beneficial for cattle fed high grain (less than 12% roughage) diets because of their role in reducing acidosis and bloat. Ionophores may not improve feed efficiency in diets with greater than 4% tallow, but they would still be effective insurance against acidosis and bloat.

In recent years, there has been a keen debate concerning the causes of antibiotic resistance and steps that should be taken (Lewis et al., 2002). This debate has been sharply divided between two major groups: 1) physicians and veterinarians who use antibiotics therapeutically to treat acute disease and 2) livestock producers who feed

antibiotics sub-therapeutically to promote (enhance) animal growth. Physicians argue that the routine use of antibiotics in animal feed creates a selection pressure for resistances that eventually spread to man. Agriculturists counter that resistance is more apt to appear when physicians and veterinarians misdiagnose infections and improperly administer antibiotics. When antibiotics are misused in this latter fashion, the dosage is greater, and the environment already has a large population of pathogens (e.g. hospitals) (Russell and Houlihan, 2003). Ruminal bacteria resistant to one ionophore can also be resistant to other ionophores (Russell and Strobel, 1989) but until recently the mechanism of this resistance was not well defined (Russell and Houlihan, 2003). Ionophores are technically considered antibiotics and for this reason, some groups have called for a ban on their use and argue that ionophore resistance poses the same public health threat as conventional antibiotics (Russell and Houlihan, 2003).

Schroeder et al. (2002) studied the antimicrobial resistance of *E. coli* O157 isolates from humans, cattle, swine and food to better understand the prevalence of antimicrobial resistance among these organisms. The authors used a total of 361 isolates, with 36% recovered from humans, 37% recovered from cattle, 19% recovered from swine, and 8% recovered from food. A total of 7 different classes of antimicrobials were used; Cephalosporins, Penicillins, Sulfonamides, Quinolones and fluoroquinolones, Phenicols, Aminoglycosides, and Tetracyclines. The authors reported that 61% of the isolates analyzed during the study were susceptible to all the antimicrobials assayed. However, 7.5% were resistant to one antimicrobial, 17% were resistant to two, 8% were resistant to three, 5% were resistant to four, 2% were resistant to five and 0.1% were resistant to six. Among the 361 isolates tested, the authors reported that 27% were resistant to

tetracycline, 26% were resistant to sulfonamides, and 23% were resistant to both antimicrobials (Schroeder et al., 2002). Of these co-resistant isolates, 57% were from swine, 19% were from cattle, 17% were from humans, and 7% were from food. Although sulfa drugs and tetracycline are approved for use in cattle, the authors could not determine conclusively whether the high rates of resistance observed among the isolates could be attributed to the use of these drugs in cattle production (Schroeder et al., 2002).

Microbiology

Ruminant animals are populated by a microbial consortium that allows the animal to convert cellulosic forages to high quality meat, milk, or fiber (Hungate 1966). The microbial population of the ruminant is very diverse and microbes are found throughout the rumen, as well as the gastrointestinal tract (Hungate 1966).

In the past, muscle tissue in the living and growing animal was thought to be sterile, or nearly so, with the exception of the lymph nodes (Romans et al., 1994). There are several types of microorganisms that can grow in/on beef. Bacteria are clearly the most predominant and important (Romans et al., 1994). Molds and yeasts are another type of microorganism (fungi) that are of minor importance in meat. Molds are more apt to cause spoilage or pose a health hazard in other types of foods although they have been shown to grow on meat products (Nuru et al., 1971). Yeasts may be involved in the spoilage of food products that contain high amounts of sugar, but since meat has only approximately 1% sugar or carbohydrates, yeasts are generally not a problem in meat. However, yeast have been isolated on rare occasions in beef cattle (Nuru et al.,1971; Romans et al., 1994).

Microorganisms of Concern in Beef Cattle Food Safety

General Microflora

Potential bacteria that can be found in beef cattle pre-harvest to fabrication include (in no particular order): *Enterococcus* sp, *Pseudomonas* sp, *Micrococcus* sp, Fecal Coliforms, *Corynebacterium* sp, *Streptomyces* sp, *Streptococcus faecalis*, *Staphylococcus aureus*, *Bacillus* sp, *Lactobacillus* sp, *Clostridium perfringens*, *Salmonella* sp, and *Escherichia coli* (Collier and Rossow, 1964; Nuru et al., 1971; Hood and Zottola, 1997). Nuru et al. (1971) reported very little differences in the microflora populations present in the feces of cattle and pigs. *E. coli* are rarely cultured in high numbers from the rumen of cattle (less than 10^6 cells/ml out of a population of 10^{10} cells/ml) (Wolin, 1969). They can be found at concentrations from 10^2 to 10^7 cells/g of feces at slaughter (Davidson and Taylor 1978).

Characteristics of *Escherichia coli*

Escherichia coli is one of the most widely spread types of microorganisms in nature (Romans et al.,1994). *E. coli* is a straight rod measuring 1.1 to 1.5 μm by 2.0 to 6.0 μm which occur singly or in pairs and has an optimum growth temperature of 37^0C. Capsules or microcapsules occur in many strains and some strains are motile by means of a flagella. *E. coli* is a facultative anaerobic bacterium that is a normal inhabitant of the mammalian intestinal tract (Drasar, 1974). *E. coli* is commonly found in human and animal intestinal tracts and, as a result of fecal contamination or contamination during food animal slaughter, it is often found in soil, water, and foods (Schroeder et al., 2002). Many *E. coli* strains are harmless and even beneficial to the host; however, some strains such as *E. coli* O157:H7 are pathogenic and cause diarrheal illness (Callaway et al.,

2003). The strains of *E. coli* that cause disease are grouped on the basis of clinical syndromes, virulence properties, mechanisms of pathogenicity, and distinct O:H serogroups (Doyle et al., 1997).

E. coli isolates are serologically classified on the basis of three major surface antigens: O (somatic), H (flagella) and K (capsule). The serogroup of the strain is identified by the O antigen and its combination with the H antigen identifies the serotype.

There are several different types of *E. coli* that have the potential to cause gastrointestinal disease in humans. They are enteropathogenic (EPEC), enterotoxigenic (ETEC), enteroinvasive (EIEC), diffuse-adhering (DAEC), and enterohaemorrhagic (EHEC) (Gorbach 1986; Doyle et al., 1997). The enteropathogenic *E. coli* (EPEC) strains attach to the brush border of intestinal epithelial cells and cause a specific type of cell damage called effacing lesions. Effacing lesions or attaching-effacing (A/E) lesions represent destruction of brush border microvilli adjacent to adhering bacteria. This cell destruction leads to diarrhea by improper absorption (Prescott et al., 1999).

The enterotoxigenic *E. coli* (ETEC) strains produce one or both of two distinct enterotoxins which are responsible for the diarrhea and distinguished by their heat stability: heat-stable enterotoxin (ST) and heat labile (LT) enterotoxin. ST binds to a glycoprotein receptor that is coupled to guanylate cyclase on the surface of intestinal epithelial cells. Activation of guanylate cyclase stimulates the production of cyclic guanosine monophosphate (cGMP), which leads to the secretion of electrolytes and water into the lumen of the small intestine, manifested as the watery diarrhea characteristic of an ETEC infection. Heat labile enterotoxin (LT) binds to specific gangliosides on the epithelial cells and activates membrane bound adenylate cyclase which leads to increased

production of cyclic adenosine monophosphate (cAMP). The result of this increased production of cAMP is hypersecretion of electrolytes and water into the intestinal lumen (Prescott et al., 1999).

The enteroinvasive *E. coli* (EIEC) strains cause non-bloody diarrhea and dysentery similar to that caused by *Shigella* spp. by penetrating and multiplying within the intestinal epithelial cells. As is the case for Shigella spp., the invasive capacity of EIEC is associated with the presence of a large plasmid (140 MDa) which encodes several outer membrane proteins (OMP's) involved in invasiveness. The principle site of bacterial localization is the colon, where EIEC invade and proliferate in epithelial cells, causing cell death (Doyle et al., 1997; Prescott et al., 1999).

The diffusely adherring *E. coli* (DAEC) strains adhere over the entire surface of epithelial cells and usually cause disease in immunologically compromised or malnourished children (Prescott et al., 1999). These strains can produce mild diarrhea without blood or fecal leukocytes and are identified by a characteristic diffuse-adherent pattern of adherence to Hep-2 or HeLa cell lines. DAEC generally do not produce heat stable or heat-labile toxins or elevated levels of Shiga toxins. They also do not invade epithelial cells (Doyle et al., 1997; Prescott et al., 1999).

The enterohemorrhagic *E. coli* (EHEC) strains carry the genetic determinants for attaching-effacing lesions and Shiga-like toxin production. The attaching-effacing lesion causes hemorrhagic colitis with severe abdominal pain and cramps followed by bloody diarrhea. The Shiga-like toxins I and II (also called verotoxins 1 and 2 due to their being cytotoxic to African green monkey kidney (Vero) cells) have also been implicated in two extraintestinal diseases; hemolytic uremic syndrome and thrombotic thrombocytopenic

purpura (Prescott et al., 1999; Callaway et al., 2003). The major foodborne pathogen associated with the EHEC group is the serotype O157:H7. Although several *E. coli* strains (i.e. O111, O26) can cause hemorrhagic colitis in humans, the most notable strain is O157:H7.

Studies have indicated that a reduction in concentration of *E. coli* in the intestinal tract of cattle may be achieved on the basis of diet manipulation (Diez-Gonzalez et al., 1998). However there are still differing opinions on whether this is possible (Hancock et al., 1999; Duncan et al., 2000). Diez-Gonzalez et al. (1998) reported that when cattle were abruptly switched from a 90% grain finishing ration to a 100% hay diet, fecal *E. coli* populations declined 1000-fold. The population of *E. coli* resistant to an "extreme" acid shock declined more than 100,000-fold within 5 days (Diez-Gonzalez et al., 1998).

Escherichia coli O157:H7

The first confirmed isolation of *Escherichia coli* O157:H7 in the United States was in 1975 from a California woman with bloody diarrhea. The bacterium was first identified as a human pathogen in 1982, when it was associated with two foodborne outbreaks of hemorrhagic colitis (Karmali et al., 1983; Riley et al., 1983). *E. coli* O157:H7 is a small, gram negative, non-sporing, straight rod. This pathogen is a facultative anaerobe and can therefore grow in the presence or absence of oxygen (Acheson, 2000). This pathogen can be encountered through the fecal oral route or through human to human transmission. It is highly acid resistant and has a low infectious dose of less than 100 cells and possibly as few as 10 cells. *E. coli* O157:H7 causes over 73,000 illnesses in the United States each year resulting in approximately 60 deaths

(Callaway et al., 2003). Enterohemorrhagic *E. coli* infections are estimated to cost the United States economy approximately $1 billion per year (USDA:ERS, 2001).

Most strains of *E. coli* O157:H7 possess several characteristics uncommon to most other *E. coli* such as the inability to grow well, if at all at temperatures of ≥44.5°C, inability to ferment sorbitol within 24 hr, and inability to produce β-glucuronidase (Doyle et al., 1997). It possesses a 60 MDa plasmid, and has an attaching and effacing (eae) gene (Doyle et al., 1997; Neill, 1997; Law, 2000). The eae gene is responsible for the production of an attaching and effacing lesion that causes the degradation and effacement of intestinal epithelial cell microvilli, adherence of bacteria to the epithelial cells, and assembly of highly organized cytoskeletal structures in the cells beneath attached bacteria (Doyle and Schoeni, 1984; Knutten et al., 1989; Raghubeer and Matches, 1990). Once *E. coli* O157:H7 attaches to the mucosa, it will grow and secrete potent cytotoxins. These cytotoxins are referred to as Shiga toxins, Shiga-like toxins, and verotoxins (Doyle and Schoeni, 1984).

Unlike most foodborne pathogens, *E. coli* O157:H7 is uniquely tolerant to acidic environments (Brackett et al., 1994). Acid-resistant *E. coli* is a potential pathogen for humans if it contaminates food because of its ability to tolerate the low pH of the gastric stomach (Fu et al., 2003). Inoculation studies conducted by Glass et al., (1992), have shown that *E. coli* O157:H7 can survive fermentation, drying, and storage of fermented sausage (pH 4.5) for up to 2 months at 4°C, with only a 100-fold reduction in cell populations. Studies conducted using lactic acid, acetic acid, or citric acid at concentrations of up to 1.5% as organic acid sprays on beef showed that *E. coli* O157:H7 cells were not significantly affected by any of the concentrations used in the study

(Brackett et al., 1994). The mechanism of acid tolerance has not been fully elucidated but appears to be associated with a protein(s) that can be induced by pre-exposing the bacteria to acid conditions (Doyle et al., 1997).

Studies conducted on the heat sensitivity of *E. coli* O157:H7 in ground beef have shown that the pathogen has no unusual resistance to heat. Heating ground beef sufficiently to kill typical strains of *Salmonella* will also kill *E. coli* O157:H7. Line et al. (1991), reported that the presence of fat increases the heat tolerance of *E. coli* O157:H7 in ground beef, with D values for lean (~2.0 % fat) and fatty (30.5 % fat) ground beef of 4.1 and 5.3 min, respectively, at 57.2°C and 0.3 and 0.5 min respectively at 62.8°C. Proper heating of foods of animal origin, i.e. heat foods to an internal temperature of at least 68°C, is an important critical control point to ensure inactivation of *E. coli* O157:H7 (Doyle et al., 1997).

The most frequently implicated vector for *E. coli* O157:H7 outbreaks has been ground beef. Bovine derived products have been linked to approximately 75% of outbreaks (Callaway et al., 2003). Most confirmed human *E. coli* O157:H7 outbreaks have been associated with the consumption of undercooked ground beef, and less frequently, unpasteurized milk; hence, cattle have been the focus of many studies to determine their involvement in transmitting the pathogen (Martin et al., 1986; Borczyk et al., 1987). Repeated outbreaks of hemorrhagic colitis linked to ground beef and/or cattle and *E. coli* O157:H7 have firmly established the connection between cattle and *E. coli* O157:H7 in the public mind. Repeated large scale recalls of contaminated ground beef, and the deaths of children who consumed foods contaminated by exposure to meat

products have further shaken the confidence of consumers in the wholesomeness and safety of beef (Callaway et al., 2003).

The first reported isolation of *E. coli* O157:H7 from cattle was from a less than 3-week-old calf with colibacillosis in Argentina in 1977 (Orskov et al., 1987). Prevalence surveys conducted on cattle estimated the overall fecal prevalence of *E. coli* O157:H7 to be very low (Elder et al, 2000). A study conducted by Wells et al. (1991) of cattle in herds associated with two cases of human *E. coli* O157:H7 infection revealed that 2.3% of calves and 3.0% of heifers, but only 0.15% of adult cows, shed *E. coli* O157:H7 in feces. Hence young animals tend to carry *E. coli* O157:H7 more frequently than adult cattle. *E. coli* O157:H7 is isolated predominantly from young animals, with the highest rate of isolation from postweaned calves (Doyle et al., 1997). Several researchers have reported that peak *E. coli* O157:H7 fecal shedding rates occur during the summer and early fall. These researchers reported shedding rates that can vary from a low of 0% to as high as 61% on some farms. To date no factors have been identified, other than season, that consistently affect the *E. coli* O157:H7 shedding rates of cattle (Heuelink et al., 1998; Jackson et al., 1998; Laegreid et al., 1999; Elder et al., 2000).

Sources of *E. coli* O157:H7 for cattle have not been clearly identified. Possible sources include contaminated feedstuffs, or water, colonized animals in herds, infected wildlife, and humans, or contaminated facilities and equipment surfaces from contact with feces (Doyle et al., 1997).

Fecal coliforms

Fecal coliforms are a group of bacteria that primarily live in the lower intestines of all warm-blooded animals, including humans. These bacteria have several traits in

common with *E. coli*: they are gram negative rods, they rapidly grow, they ferment lactose, and they do not form spores. *E. coli* is considered a type of fecal coliform. Fecal coliforms such as *E. coli*, as the name implies, are frequently found in the feces of warm-blooded animals including humans. Because they are found in feces, fecal coliforms have been used as 'indicator bacteria' to detect the presence of fecal contamination in food and water (Henken and Cocanougher, 1998).

Characteristics of *Salmonella*

Salmonella spp. are gram-negative non-spore forming, ova-shaped, facultative anaerobes. These organisms produce gas from glucose and utilize citrate as their sole carbon source (D'Aoust 1989; Takaya et al., 2002). They produce hydrogen sulfide gas, decarboxylate lysine, and ornithine but are urease-negative and do not produce indole (D'Aoust 1989). The rate of growth is dependent on temperature, pH, salinity, water activity (a_w), and nutrient level of the suspending medium (D'Aoust, 1989; Guthrie, 1992). Salmonellae are considered to be mesophilic bacteria with a temperature growth range of 8-45°C; with optimum growth occurring in the range of 35-37°C (D'Aoust, 1989; Guthrie, 1992). The organisms' growth can be inhibited at temperatures below 6.7°C; however, they are not killed and will resume growth if the temperature is returned within the optimal range (Nickerson and Sinskey, 1972). *Salmonella* bacteria are killed at temperatures 70°C or above. Due to this characteristic, cooking for the amount of time it takes to reach this temperature throughout the food being cooked is sufficient to destroy *Salmonella* cells. The growth of *Salmonella* is generally inhibited in the presence of 3-4% NaCl (D'Aoust, 1989). Their optimum pH range for growth is between 6.5-7.5 but it has been shown that they can grow at pH ranges from 4 to 9. *Salmonella,* need a water

activity (a_w) level of above 0.94 to grow with optimal growth occurring at 0.99 (D'Aoust, 1989).

Salmonella is not species specific (equine, poultry, swine, and bovine) and can be transferred from animal to man through undercooked meat, raw eggs, or feces. Animals can carry *Salmonella* species until they go to slaughter, or animal products may be contaminated during processing and preparation (Cooke, 1996; Prescott et al., 1999). They may be present in the intestinal tract and other tissues of red meat animals and poultry without producing any apparent symptoms of infection in the animal (Marriot, 1999).

Parasites

All cattle are victims of internal nematode (worms) parasitism as long as they are maintained on pasture. Gastrointestinal parasites are a major constraint to animal health, productivity, and profitability in grazing livestock production systems (Stuedemann et al., 2004). Anything that negates profitability results in loss to the producer and to the livestock economy. Thus parasites negatively affect the economy of the industry (Corwin, 1997). Worldwide, gastrointestinal nematode parasites and those of the respiratory tract have a potentially major impact on herd health (Corwin, 1997). Parasite free pastures would improve cattle health and performance, resulting in possible economic return to producers (Stuedemann et al., 2004).

The impact of parasitism on the health of animals in general includes but is not limited to production losses due to depressed appetite, reduced feed digestibility, and/or disruption of normal metabolic or hormonal processes (Dargie 1987; Williams et al.,1992; Herd, 1993). A severe parasitic load can result in weight loss, slow growth rates

of animals, and ultimately a loss in potential profits. In extreme conditions, heavy parasitic infestation can lead to death (McGowan, 2003).

The effects of internal parasites on cattle will vary with the severity of infection as well as age and stress level of the animal. In general, younger animals and animals under stress are most likely to show signs of parasitism. Mature cows acquire a degree of immunity to parasites that reside in the lower gastrointestinal tract (Gadberry et al., 2004; Loyacano et al., 2002). In addition, parasite burdens are most detrimental in mature cows near parturition because immunity is suppressed. Cows, especially dairy, in early lactation are often in a negative energy balance due to the stress of lactation. These cattle are affected more by parasitism than cows in later lactation, when smaller levels of milk are being produced. Bulls are more susceptible to internal parasites than cows (Gadberry et al., 2004).

The effects of parasitism can be separated into two types – subclinical and clinical. Losses in animal productivity (milk production, weight gain, altered carcass composition, conception rate, etc.) are all subclinical effects; whereas, visible disease-like symptoms (roughness of coat, anemia, edema, diarrhea) are clinical effects. The subclinical effects are of major economic importance to the producer (Gadberry et al., 2004).

In an effort to determine whether or not an animal is ill due to internal parasites, taking a fecal sample and examining it for the presence of parasite eggs is essential. This is also necessary to avoid wasting money treating an animal needlessly. The flotation method is based on the differential specific gravity of parasite eggs/oocysts and fecal debris. Eggs and oocysts float in saturated sugar or salt solutions, while most debris settles. By knowing just what type of eggs are present and an estimate of how many, it

can be decided if an animal or herd needs to be treated and if so which drugs to use (Tritschler *and* LeaMaster, 1998).

There are two main types of parasite infestations in cattle: internal and external. Major external parasites include horn flies, house flies, stable flies, horse flies, deer flies, black flies, mosquitoes, cattle grubs, mites, ticks, and lice. Gastrointestinal worms inhabit specific areas from the abomasum to the colon. There are many species, and all can cause serious loss of condition (Catcott, 1977). Parasitized cattle are harmed, not only by the parasites themselves, but also by the indirect damage the parasites cause to the immune system (Bliss, 1999). Major internal parasites include stomach worms, lung worms, liver flukes, and coccidia.

Haemonchus spp. also known as stomach worms, hairworms, barber's pole worm, blood worm and "humongous" worm. *Haemonchus* spp. or stomach worms, are nematodes found in the abomasum, intestine and lungs of cattle. The most common of these is the brown worm, which causes non-specific immunosuppressive effects. The brown stomach worm can destroy important glands located in the abomasum resulting in loss of serum proteins, reduced acidity and diarrhea. This nematode parasite causes inefficient feed utilization, depressed milk production and lighter calves at weaning (Larson, 1997). Most *Haemonchus* worms are transmitted when infected cattle pass eggs in manure onto the ground, eggs hatch in the manure, rain washes the larvae from the manure and cattle swallow larvae on wet grass in moderate temperatures (Larson, 1997). In regions such as the southeast and south-central United States, nematode parasitism is a fact of life and without some form of effective prevention and control, losses in

productivity or deaths will occur (Larson, 1997). *Haemonchus* worms cannot be seen in the manure. A diagnosis is made by finding worm eggs under the microscope.

Lung worms cause a lung disease in cattle with clinical signs similar to those caused by viruses, bacteria and allergies. Transmission is similar to that of hairworms. Lung worm disease occurs in previously unexposed cattle, such as calves (Faries, 1998). Lung worms cause respiratory problems in calves and yearlings (Worley, 2000), and lung worms cause pneumonia and provide an environment conducive for viral and bacterial pneumonia, with labored breathing and anxiety leading to depressed performance (Corwin and Randle, 1993).

Liver fluke infections may be developed in cattle living in wet areas with alkaline soils. Clinical signs of liver fluke infestation are evident and cause digestive inefficiency in young cattle with acute liver disease or in older cattle with chronic liver disease. Liver flukes are transmitted when infected cattle, deer and rabbits pass eggs in manure and drop the manure in water, eggs hatch in water and larvae develop in snails, and cattle swallow cysts on grass or hay. Cattle with liver flukes have symptoms similar to those with malnutrition and hairworms (Faries, 1998).

A major parasite that is a problem in many parts of the world including Florida is a group of protozoa collectively called coccidia. The most important of these belong to the genera of Eimeria. Coccidiosis continues to be one of the major disease problems for cattle producers. Coccidia are protozoan parasites that are host specific. The oocyst, or infective form of the parasite, is usually shed in the feces of affected animals or carrier animals. The oocyst is highly resistant and can survive for years (Kirkpatrick and Selk, 2000).

Coccidiosis occurs more frequently in calves from one to six months of age, but older cattle, especially those from one to two years, are often affected (Ferguson, 1996). Coccidiosis in cattle usually presents as acute diarrhea, with or without blood, straining, severe weight loss, and not uncommonly as a neurologic form which usually results in death of the animal. The more chronic form causes growth retardation and/or is a stressor causing an increased susceptibility to other infections. Coccidiosis is transmitted from animal to animal by the fecal-oral route. Infected fecal material contaminating feed, water or soil serves as carriers for the oocyst for the susceptible animal to contract by eating, drinking, or licking itself. The severity of the clinical disease depends on the number of oocysts ingested (Kirkpatrick and Selk, 2000).

Most cattle producers recognize that internal parasite infestation can damage their livestock. Treatment with one or several dewormers is commonly applied. Strategic deworming is the term in common use for preventing nematodes in beef cattle by stopping pasture contamination. Too often deworming occurs when it is convenient or when the cattle are being handled (Kvasnicka et al., 1998). The objective of strategic deworming is to reduce parasite challenge by lowering parasite numbers on the pasture and inside the animal. Hamilton and Giesen, (1997) reported that grazing yearling cattle treated with a formulation of the dewormer fenbendazole (Safeguard, Hoescht) had increased weight gains compared with control cattle. After 6 weeks of grazing, treated cattle had 0% fecal samples positive for worm eggs, while control cattle had 50% positive samples.

Dewormers are administered to cattle to kill internal parasites and stop damage caused by these parasites. Administering drugs at the right time is critical to stop parasite

life cycles. The effective ingredients in dewormers include chemicals such as lasalocid, sulfonamides, amprolium, benzimidazoles, albendazole, fenbendazole, oxfendazole, ivermectin, levamisole and morantel. Once a parasite population is established within a herd of cattle, they must be identified and treated. Accurate, specific and regular treatment is the only path to elimination and prevention of parasites in a cow-calf herd. A strategic deworming program must be outlined specifically for each ranch and for each cattle management plan.

Sensory Characteristics of Beef

Palatability characteristics, such as flavor and tenderness, are major factors influencing consumer acceptance of beef and beef products. Research in the past has concentrated on identifying certain production variables, such as feeding and management programs, which may affect beef palatability (Xiong et al., 1996). Some authors concluded that beef flavor from forage-fed cattle was not negatively affected (Oltjen et al., 1971; Cross &Dinius, 1978), whereas most other reports indicated beef from forage fed-cattle had a less desirable flavor (e.g. "grassy") than that from grain-fed cattle (Reagan et al., 1977; Bowling et al., 1978). The undesirable flavor in forage fed beef is attributed mainly to volatiles, which are soluble in the lipid component (Larick & Turner, 1990). Forage finishing of beef has not been recommended in the past due to lower dressing percent, decreased quality grade, yellow fat color, dark muscle color, and decreased flavor and tenderness relative to grain-fed beef (Mandell et al., 1997). In contrast, other studies (Bidner et al., 1981; Fortin et al., 1985; McCaughey and Clipef 1996) generally found no differences in palatability attributes between forage- and grain-finished beef (Mandell et al., 1997).

Several factors have been identified as general predictors of whether beef will be acceptably tender. Most notable among these factors are age and sex of the animal (Huff and Parrish, 1993). Beef from more mature animals repeatedly has been found less tender than beef from younger animals (Tuma et al., 1963; Dikeman and Tuma, 1971; Smith et al., 1982). Sex of the animal (castrated vs non-castrated males), however, has been shown to have somewhat less of a definitive effect upon tenderness (Huff and Parrish, 1993).

Meat quality is an important criterion that influences the decision of a consumer to purchase beef. Many investigators (Maltin et al., 2001; Mandell et al., 1998; May et al., 1992; Moloney et al., 2001; Sinclair et al., 1998) studied the relation among different production factors (feeding plan, age, breed, gender, etc.) and sensory attributes (tenderness, juiciness, flavor, texture, color). Among the factors that influence consumer perception of meat quality are tenderness (Chrystall, 1994), color (Baardseth et al., 1988), juiciness (Hutchings and Illford, 1988) and flavor (Melton, 1990).

As grain prices increase, interest in beef cattle forage-finishing systems also increases. Climate and forage resources could allow the southeastern United States the opportunity to utilize alternative finishing systems although cow-calf operations predominate the Southeast (Sapp et al., 1996). Forage-fed beef has been discriminated against due to lean color, lower palatability, off flavors, and less retail stability which limits consumer acceptability (Sapp et al., 1996).

Sapp et al. (1996) conducted a study to compare pasture-fed (wheat-ryegrass) and grain-fed beef from young Angus steers for palatability, storage and shelf life characteristics. A total of 60 animals over two years were subjected to one of three

postweaning feeding programs wheat-ryegrass pasture only, wheat-ryegrass pasture followed by grain, and a mixed ration in drylot fed ad libitum. The researchers reported that pasture-fed beef and grain fed beef were similar in sensory panel tenderness scores but pasture/grain-beef was less tender than either the pasture-fed or grain-fed beef. The reason for this difference could have been due to connective tissue content of the pasture/grain-fed beef. Sensory panel connective tissue scores reflected tenderness scores with pasture- and grain-fed beef containing less connective tissue. The researchers reported that grain-fed beef was juicier than pasture- and pasture/grain-fed beef according to sensory panel scores. Schroeder et al. (1980) reported higher juiciness scores for steaks from grain-fed cattle versus steaks from forage-fed cattle. Juiciness is usually associated with intramuscular fat and as a result the differences could be due to marbling differences between the treatment groups (Sapp et al., 1996). Breidenstein et al. (1968) and Gilpin et al. (1965) found that steaks from carcasses with higher marbling scores were associated with consistently higher juiciness ratings when evaluated by sensory panels. Sapp et al. (1996) reported no flavor differences between grain-, pasture- and pasture/grain-fed beef. However, other researchers have reported lower flavor scores for forage-fed beef compared to grain-fed beef. Schroeder et al. (1980) reported higher flavor scores for steaks from grain-fed cattle versus forage-fed cattle. Bowling et al. (1977), Harrison et al. (1978), and Meyer et al. (1960) all found that forage-fed beef had lower flavor desirability scores. Sapp et al. (1996) also reported that pasture/grain-fed and grain-fed beef displayed lower incidence of off flavor than pasture-fed beef.

While there is evidence, particularly from North American beef production systems, that concentrate-fed animals produce more tender and better flavored meat than forage-

fed animals (Sapp et al., 1996; French et al., 2000), dietary effects in many of these experiments are confounded by differences in animal age or carcass weight at slaughter (Bowling et al., 1978; Harrison et al., 1978). When both feeds are offered ad libitum, carcass growth of concentrate-fed cattle is often higher relative to animals fed grazed grass or other forages. Thus, concentrate-fed animals have heavier and fatter carcasses than forage-fed animals when grown for a constant time period or may be younger when grown to a specific body weight or back fat thickness (French et al., 2000). Carcass weight, back fat thickness, age at slaughter and pre-slaughter growth rate have all been shown to alter meat quality, specifically tenderness and flavor (French et al., 2000).

Objective Characteristics

Color

Color is an extremely critical component of the appearance of fresh beef sold through retail, and among visual characteristics has substantial influence on purchase decisions. Muscle color is an important criterion by which many consumers evaluate meat quality and acceptability. In red meats, consumers relate a bright-red color to freshness, but discriminate against meat that has turned brown (O'Sullivan et al., 2004; Sami et al., 2004).

Retaining cattle after weaning and even to a finished weight, and allocating different types of beef cattle to forage can allow an option for increased productivity and profit to producers. However, on a similar time scale, forage-fed cattle typically do not have the same degree of finish as grain-fed cattle due to the decreased energy available in the forage (Baublits et al., 2004). Although typical forage-fed beef is lean and warrants an acceptable USDA yield grade, it is often inferior to traditional grain-fed beef in terms

of both USDA quality grade and has a darker lean color as well as a more yellow fat color (Priolo et al., 2001; Morgan et al., 1969). The color of the lean and external fat cuts of meat has been shown to be influential on the purchasing ability and visual acceptability by the consumer (Baublits et al., 2004).

Typically, forage-based rations, as well as different forages and seasonal changes, allow for carcasses with a darker lean appearance or fat that is yellow in appearance. The darker lean can be attributed to increased myoglobin, decreased muscle glycogen, or both, and the yellow fat is due to forages having increased carotenoids (which are deposited in adipose tissue) compared to concentrates (Priolo et al., 2001). A study conducted by Baublits et al. (2004) examined beef lean color characteristics of steers and heifers grazing cool season forages supplemented with soyhulls. The forages used were tall fescue (Fescue) and orchardgrass (Orchard). These authors reported lower L* values for control animals that grazed Fescue pasture with no supplementation compared to animals that grazed Fescue and Orchard but were supplemented with pelleted soy hulls. The authors could not determine the exact cause for the lower L* values in control carcasses but it was thought that it could be due to differences in antemortem muscle glycogen and its effect on the pH of the meat. Vestergaard et al. (2000) reported less glycogen, a higher pH, and darker lean for longissimus muscle from young bulls that were fed a forage-limited diet compared to young bulls fed concentrates ad libitum. Baublits et al. (2004) reported lower b* values, indicating degree of yellow appearance, for control animals than that of Fescue or Orchard animals. The differences were thought to be due to muscle pH. Page et al. (2001) reported a negative correlation between pH and b values. Therefore, if the cattle had less muscle glycogen at the time of slaughter, then a higher

muscle pH and lower lean b* values could have been the result. Carotenoid concentrations in adipose tissue could also have an effect upon yellowness and b* values (Morgan et al., 1969). Baublits et al. (2004) reported no differences between treatments for objective adipose color, therefore illustrating that carotenoid concentrations in their study did not contribute to the differences in yellowness of the lean color. Bennett et al. (1995) reported that the lean color of steers finished on rhizoma peanut tropical grass pasture, was darker than that of concentrate finished steers. Bidner et al. (1981) and Reagan et al. (1977) both reported a darker lean color for forage fed animals in comparison with concentrate-fed animals. Both of these authors attributed part of the darker lean color to a higher myoglobin concentration in the longissimus muscle of forage finished steers. The heme pigment, myoglobin is mainly responsible for the color of meat. Varnam and Sutherland (1995) hypothesized that grass-fed animals have more muscle myoglobin, due to more activity pre-slaughter than their feedlot counterparts.

Tenderness

Meat tenderness, and the factors that affect it, have been studied for many years. Tenderness can vary from animal to animal, from muscle to muscle within an animal, and from area to area within a muscle (Bourne, 1982). Tenderness is further affected by processing treatments applied to the animal. Many studies have shown that tenderness can be significantly decreased in beef if the muscle is removed from the carcass before proper aging is completed (Kastner, 1983; Jeremiah et al., 1985). Differences in the rate and extent of postmortem tenderization are the principle sources of variation in meat tenderness and are probably the source of inconsistency in meat tenderness at the consumer level. To solve the tenderness problem, an even greater understanding of the

mechanisms regulating meat tenderness and tenderization must be gained (Koohmaraie et al., 1996).

Tenderness is extremely difficult to measure objectively because the chewing motions involved in mastication involve both vertical and lateral movements of the human jaw as well as various in-between modifications, which together produce the impression of tenderness (Pearson, 1963). A number of objective methods for evaluating meat tenderness have been developed. One of the first to be developed, and one still widely used, is the Warner-Bratzler shear WBS (Bratzler, 1932). The WBS method uses a single blade to shear a uniform core of meat, and registers the maximum or peak load necessary to effect the shear.

Due to time and money, it is very difficult to maintain a well-trained sensory panel, to evaluate meat characteristics from different studies. Tenderness of a cooked meat samples can be assessed much more easily using WBS than a trained sensory panel analysis (Shackelford et al., 1995). Harris and Shorthose (1988) reported that shear force does not accurately reflect tenderness differences among muscles, however most researchers rely upon WBS for objective estimates of tenderness (Smith et al., 1978). Several authors have found positive correlations between sensory panel tenderness ratings and WBS values for the same muscles, which suggest that WBS is reliable to use in lieu of trained sensory panel results (Brady, 1937; Kropf and Graf, 1959; Alsmeyer et al., 1966).

Schaake et al. (1993) conducted a study comparing steers that were fed exclusively fescue clover pasture, pastured on fescue clover then placed on summer pastures (i.e. sorghum sudangrass, millet, coastal bermudagrass, or Tifton 44 bermudagrass), pastured

on fescue-clover and then placed in a drylot for 45, or 75 days, and steers that were placed in a drylot after weaning and conditioning. The researchers reported that the steaks from the carcasses of the steers that were placed in the drylot after weaning and conditioning were most tender according to WBS measurements but did not differ from steaks from summer pasture-fed animals (Schaake et al., 1993). According to a trained taste panel done in the same study, panelists found steaks from the summer pasture-fed steers to be more tender but otherwise similar to steaks from the long term drylot steers in agreement with the WBS measurements (Schaake et al., 1993). Sapp et al. (1996) reported that WBS values for strip loin steaks from pasture/grain-fed steers were higher than steaks from grain-fed steers. Smith et al. (1978) suggested that shear force and trained sensory panel tenderness ratings are sufficiently correlated to justify the use of either measure for assessing the tenderness of muscles in a beef carcass.

MATERIALS AND METHODS

Experiments were conducted to evaluate the effects of three feeding regimens on performance, microbiology, sensory and objective characteristics of beef cattle. The study was conducted at the University of Florida's Boston Farm - Santa Fe River Ranch Beef Unit at Alachua, Florida. The study was conducted over three consecutive years – Summer 2002 to Spring 2003 and Fall 2003 to Spring 2005. Two experiments were conducted. A total of 60 Brangus cattle were employed in the study. Experiments One and Two, utilized a complete random design with 30 Brangus beef cattle with three treatments, and ten replicate cattle per treatment per experiment.

Animals

The animals in Experiment One ranged in age from 15 to 18 months of age with an average age of 17 months. The average initial weight of the cattle during this experiment was 344.73 kg. The cattle in Experiment Two ranged in age from 8 to 10 months with an average age of 9 months. The average initial weight of the cattle during this experiment was 247.21 kg. All animals used in the study had been vaccinated and were weaned. All animals were dewormed using a dewormer with ivermectin injectible prior to the start of each experiment. Animals were tagged with an identification label that corresponded to its treatment group. Appropriate feeding, and care management practices were employed for all animals. Approved medications (Liquamycin) were administered as needed to

insure the health of all animals. This study was approved by the Institutional Animal Care and Use Committee (IACUC).

Animal Diets and Feeding Procedure

Animal diets in both Experiment One and Experiment Two, consisted of two different isoprotein diets and bahiagrass ad libitum. The first treatment group of ten animals received a commercially available 12% protein non-medicated concentrate (F-R-M Super 12, Flint River Mills Inc., Bainbridge, GA) once per day in addition to being allowed to graze in a 2-acre plot of fertilized bahiagrass pasture. The second treatment group of ten animals received a commercially available 12% protein concentrate that contained a coccidiostat "lasalocid" (Cattle Pasture Supplement B-80 Medicated, Flint River Mills Inc., Bainbridge, GA) once per day in addition to being allowed to graze a 2-acre plot of fertilized bahiagrass pasture. The third treatment group of ten animals was only allowed to graze ad libitum in a 2-acre plot of fertilized bahiagrass pasture. The Super 12 concentrate contained corn chops, wheat middlings, rice mill by-product, cane molasses, salt, Vitamin A supplement, Vitamin D-3 supplement, and minerals. The Cattle Pasture Supplement B-80 Medicated concentrate contained, lasalocid, cottonseed meal, corn meal, soybean meal, rice mill by product, animal fat stabilized with BHA, urea, Vitamin A supplement, Vitamin D-3 supplement, salt, and minerals. All three groups of steers were given a mineral mix (Special UF Mineral Mix, University of Florida, Gainesville, Fl) which contained calcium, phosphorous, salt, magnesium, copper, cobalt, iodine, manganese, selenium, and fluorine. The amount of each concentrate supplement was regulated on the basis of total consumption. The Super 12 concentrate was initially fed at a rate of 2.3 kg (5 lb) per animal to its respective group of animals. It

was increased 0.5 kg (1 lb) to a maximum of 11.4 kg (25 lbs) per animal/day unless there was feed left from the previous day in which case the same amount as the previous day was given. According to manufacturer instructions, each pound of B-80 medicated concentrate provided 40 mg of lasalocid and was to be fed continuously at a rate of no less than 60 mg nor no more than 200 mg of lasalocid per animal per day. The B-80 medicated concentrate was given initially at a rate of 0.7 kg (1.5 lbs) per animal. It was increased 0.1 kg (0.25 lbs) to a maximum of 2.3 kg (5 lbs) per animal/day unless there was feed left from the previous day in which case the amount given either remained the same as the previous day or was reduced 0.1 kg.

Weight, Fecal, and Blood Collection

The animals were weighed every 28 days until the project target weight of 453 ± 22 kg (1000 ± 50 lbs) was reached. From these weights, average daily gain (ADG) was calculated. Fecal samples were also collected from each animal on the weighing date. Fecal sample collection consisted of taking a rectal sample directly from the animal and placing it into a sterile container (Fisher Scientific, Pittsburgh, PA 15238). The fecal samples were then divided in half. Half of the sample was transported to the Meat Science microbiology laboratory for analysis, and the remaining half was taken to Florida A&M University for analysis of parasites. During Experiment One, blood samples were collected every 28 days using blood collection needles (Vaccutainer, Franklin Lakes, NJ, 02685A) and Vaccutainer blood collection tubes without coagulant (Vaccutainer, Franklin Lakes, NJ, 02685A). During Experiment Two, blood samples were collected at the beginning of the trial and then again at the end of the trial. Blood samples were transported to University of Florida Veterinary Science Department and analyzed for total

blood chemistry. Total blood chemistry included analyzing for albumin, alkaline phosphate (Alk Phos), anion gap, aspartate amino transferase (AST), bilirubin, blood urea nitrogen, calcium, carbon dioxide, chloride, creatinine, gamma glutamyl transpeptidase (Gamma GT), globulin, glucose, magnesium, phosphorous, potassium, sodium, and total protein.

Microbiological Analysis

Twenty-five grams of each fecal sample were taken and placed in sterile 18 x 30 cm Fisherbrand stomacher bags (400 ml, Fisher Scientific, Pittsburgh, PA 15238) along with 250 ml of sterile 0.1% peptone water. The stomacher bags were stomached in a stomacher (Tekmar Company, Cincinnati, Ohio, 45222 Model #400) for two minutes. One milliliter of the sample diluent from the stomacher bag, 1:10 solution, was transferred to a test tube containing 9 ml of sterile 0.1% peptone water from which 10^{-2} to 10^{-5} were prepared. One µl from the dilutions was pipetted onto Soribitol MacConkey Agar (SMAC, Difco Laboratories, Detroit, MI 46232-7058, Cat. No. DF0078-17-7) for the detection of generic *Escherichia coli* and *Escherichia coli* O157:H7 and spread onto the plates using a glass hockey stick, which was flame sterilized before spreading. One µl from the same dilutions was pipetted onto Tryptic Soy Agar (TSA, Difco Laboratories, Detroit, MI 46232-7058, Cat. No. DF0369-17-6), and onto mFC Agar (media for enumeration of fecal coliforms, Difco Laboratories, Detroit, MI 46232-7058, Cat. No. DF0677-17-3) for the detection of aerobic bacteria and fecal coliforms respectively. In addition one µl was also pipetted onto Xylose Lysine Desoxycholate Agar (XLD, Difco Laboratories, Detroit, MI 48232-7058, Cat. No. DFO 788-17-9) and Hektoen Enteric Agar (HE, Difco Laboratories, Detroit, MI 48232-7058, Cat. No. DFO 853-17-9) for the

direct detection of *Salmonella* organisms. All plates were prepared in duplicate. The SMAC plates were incubated at 35°C for 24 hours. The TSA, XLD, and HE plates were incubated at 37°C for 24 hours. The mFC plates were incubated at 43°C for 24 hours. After 24 hours of incubation, typical generic *E. coli* and *E. coli* O157:H7 colony forming units from the SMAC plates were enumerated and averaged. Following 24 hour incubation, colony forming units (CFU) from the TSA and mFC plates were counted, averaged, and recorded as total aerobic bacteria, and fecal coliform bacteria, respectively. After incubation period, typical *Salmonella* CFU from the XLD and HE plates were enumerated and averaged.

The presence of *Salmonella* was determined by placing 1g of fecal sample into 9 ml of lactose broth and incubated at room temperature for 60 min. After incubation at room temperature, the sample was then incubated at 35°C for 24 hours. After 24 hour incubation 0.1 ml of the broth was transferred to 10 ml of Rappaport-Vassiliadis (RV, Difco Laboratories, Detroit, MI, 48232-7058, Cat. no. DFO 1858-17). The RV medium was then incubated at 43°C for 24 hours. After this incubation a loopful of the RV sample was streaked onto XLD and HE agar and the plates were incubated for 24 hours at 37°C. After 24 hours the plates were examined for typical *Salmonella* and recorded.

Except for the substitution of Violet Red Bile Agar (VRBA, Difco Laboratories, Detroit, MI, 48232-7058, Cat. No. DF0012177) for SMAC media, all microbial analyses were the same for Experiment Two. The SMAC media was substituted due to the fact that VRBA produced more of a distinct color difference between generic *E. coli* and *E. coli* O157:H7.

Parasite Analysis

Coccidia, *Haemonchus*, and *Moniezia* parasite analysis was conducted using a fecal flotation method (Tritschler and LeaMaster, 1998). One gram of fecal sample was placed into a jar along with enough water to form a 1:10 ratio of sample to water. The jar was then shaken to disperse the fecal material. A 1.5 ml aliquot of the mixture was transferred to a test tube. The test tube was then filled with a concentrated salt solution until a meniscus was formed at the top. A glass slide was placed over the tube for approximately 15 ± 5 minutes. The slide was then examined under a microscope moving from edge to edge. When worm like eggs were observed, the microscope was focused to determine identification. A descriptive chart was used to verify the type of eggs being observed. A qualitative and quantitative count was conducted. The number of eggs per gram (EPG) of feces was calculated using the following formula: EPG = (grams of feces + ml of fluid)/grams of feces x 1/3 x (no. of eggs counted).

Environmental Samples

Bahiagrass

Three grass samples per plot were randomly collected at the beginning and the end of Experiment One from the two acre plots where each group of steers grazed. Samples were collected during the month of June (early summer), and then again during the month of November (late fall). During Experiment Two, three random grass samples per plot were collected at the beginning and the end of the experiment from the plots where each group of steers grazed. Samples were taken once during November (late fall) and again during June (early summer). All samples were analyzed for moisture (AOAC 930.04), fat (AOAC 930.09), crude protein (AOAC 978.04), ash (AOAC 930.05), neutral detergent

fiber (NDF) and acid detergent fiber (ADF) (during Experiment Two only) (AOAC, 1997; Van Soest and Robertson, 1985). The total fiber content of the grass was estimated by difference (i.e. total fiber) during Experiment One.

Microbial analysis of the grass included enumerating aerobic organisms, fecal coliforms, generic *E. coli* and *E. coli* O157:H7, and evaluating for the presence of *Salmonella* spp. Enumeration involved aseptically transferring 25g of bahiagrass into a sterile stomacher bag, making a 1:10 dilution with 0.1% peptone water. The sample was stomached for 2 min. Serial dilutions were made with 0.1% peptone water. Dilutions were then transferred and spread onto selective media. Aerobic organisms were enumerated on TSA. *E. coli* organisms were enumerated on SMAC. The presence of *Salmonella* was done as previously described. TSA plates were incubated at 37°C for 24 hours. SMAC plates were incubated at 35°C for 24 hours. After 24 hour incubation, colonies were enumerated, and averaged.

Animal Drinking Water

Three samples of animal drinking water were taken directly from the animal drinking supply. Sterile container cups (Fisher Scientific, Pittsburgh, PA 15238, Cat. no. 14-375-147) were opened and placed into the animal drinking water supply. Cups were then sealed and transported back to the meat science laboratory for microbial analysis.

Animal drinking water was analyzed for aerobic bacteria, *E. coli*, *E. coli* O157:H7, fecal coliforms, and *Salmonella*. A 0.1 µl aliquot was taken from the undiluted sample and spread evenly onto selective media. Aerobic organisms were enumerated on TSA. *E. coli* organisms were enumerated on SMAC. *Salmonella* organisms were enumerated on XLD and HE plates.

Animal Feed

Three grab samples were aseptically collected in sterile cups at the beginning and at the end of experiment one from each of the two commercially available animal feeds. Cups were sealed, labeled and transported to the meat science laboratory for microbial analysis. Animal feed was analyzed for aerobic bacteria, *E. coli*, *E. coli* O157:H7, fecal coliforms, and *Salmonella*.

Twenty-five grams of animal feed were added to a sterile stomacher bag along with 225 ml of 0.1% peptone water to prepare a 1:10 dilution. The sample was then stomached in a stomacher for 2 min. Serial dilutions with 0.1% peptone water were prepared and spread onto selective media. Aerobic organisms were enumerated on TSA. *E. coli* organisms were enumerated on SMAC. The analysis for presence of *Salmonella* was conducted as previously described. TSA plates were incubated at 37°C for 24 hours. SMAC plates were incubated at 35°C for 24 hours. After 24 hour incubation, CFU's were enumerated and averaged.

Animal Slaughter and Carcass Characteristics

When at least ten animals irrespective of treatment, reached the target weight of 453.6 ± 22.7 kg (1000 ± 50 lbs) that group of ten animals were transported to Central Beef Company, Center Hill, Florida for slaughter. The remaining 20 animals irrespective of treatment were then placed on the F-R-M Super 12 commercial feed until the target weight range was reached. Once that target weight range was reached, the remaining 20 animals were then transported and slaughtered at a commercial United States Department of Agriculture (USDA) inspected plant. Carcass weights were recorded for each animal. The resulting carcasses were split longitudinally, rinsed and sprayed with a 2% lactic acid

solution for microbial intervention and chilled for 24 hours in a 1 ± 2°C cooler. The chilled carcasses were ribbed and evaluated subjectively by trained meat staff personnel for hot carcass weight, USDA yield grade, marbling score, fat over the eye, measured rib eye area, lean color, lean texture, and lean firmness. Lean color was determined using an eight point rating scale: (1= dark pink, 2= very light cherry red, 3= light cherry red, 4= slightly light cherry red, 5= cherry red, 6= moderately dark red, 7= dark red, 8= very dark red). Lean texture was determined using a seven point scale: (1= very fine, 2= fine, 3= moderately fine, 4= slightly coarse, 5= coarse, 6= very coarse, 7= extremely coarse). Lean firmness was determined using a seven point scale: (1= very firm, 2= firm, 3= moderately firm, 4= slightly soft, 5= soft, 6= very soft, 7= extremely soft). The short loin portion of each animal (between the 12th rib and the sirloin area, including the 13th rib excluding the flank) was then harvested and cut into steaks for sensory analysis, pH, Warner Bratzler Shear (WBS), and objective color analysis.

Sensory Analysis

Steaks were cut from the short loin portion of each animal. Individual steaks were vacuum sealed in Cryovac B550T (Sealed Air Corp., Duncan, SC) bags and subsequently heat shrunk in 82°C water as per manufacturers recommendation. Steaks were then subjected to postmortem aging for 14 days at 2 ± 2°C in a walk in cooler. After the postmortem aging period, steaks were frozen at -40 ± 2°C then transferred to a -20 ± 2°C holding freezer until sensory analysis was conducted. Steaks were thawed for 18 hours at 2 to 4°C then broiled on Faberware (Farberware, Bronx, NY) open-hearth broilers to an internal temperature of 71°C (American Meat Science Association, 1995). The housing and drip pans of each broiler were covered with aluminum foil and preheated for 15 min.

Copper-constantan thermocouples (Omega Engineering, Inc., Stamford, CT) were placed in the approximate geometric center of each steak and used to record internal temperature. Steaks were turned when the internal temperature of 35°C was reached and removed from the broiler when the internal temperature reached 71°C. Weight in grams was recorded while the steaks were frozen, after thawing, and after cooking for calculation of cook loss and thaw loss.

A sensory panel of 7 to 11 trained panelists were used to evaluate all samples for 5 characteristics using the following trait and rating scales: juiciness (8 = extremely juicy, 7 = very juicy, 6 = moderately juicy, 5 = slightly juicy, 4 = slightly dry, 3 = moderately dry, 2 = very dry, and 1 = extremely dry); beef flavor intensity (8 = extremely intense, 7 = very intense, 6 = moderately intense, 5 = slightly intense, 4 = slightly bland, 3 = moderately bland, 2 = very bland, and 1 = extremely bland); overall tenderness (8 = extremely tender, 7 = very tender, 6 = moderately tender, 5 = slightly tender, 4 = slightly tough, 3 = moderately tough, 2 = very tough, and 1 = extremely tough); connective tissue (8 = none detected, 7 = practically none, 6 = trace amounts, 5 = slight amount, 4 = moderate amount, 3 = slightly abundant, 2 = moderately abundant, and 1 = abundant amount); off flavor (6 = none detected, 5 = threshold; barely detected, 4 = slight off-flavor, 3 = moderate off-flavor, 2 = strong off-flavor, and 1 = extreme off-flavor). Panelists were also asked to identify any off-flavors that may have been detected such as rancidity, salty, sweet, sour, fishy, bitter, metallic, sulfur, soapy, garlic, and grassy. At each session, panelists were served 5 samples, a warm-up sample, water for rinsing their pallets, and unsalted crackers. The lighting in the room consisted of using red and white

fluorescent lighting. The sensory panel required approval from the University of Florida Review Board in order to be conducted.

Objective Color Analysis

Instrumental color data were obtained 48 hours postmortem by using a Minolta chromatographer (Model CR-300; Minolta Corp., Ramsey, NJ). Upon ribbing of the carcass and exposure of the longissimus muscle at the 12th rib, a blooming period of approximately 30 min was utilized before instrumental color analysis. Instrumental color data of the lean was measured using the L* a* b* color spectrum. This spectrum includes L* (lightness) which is a measure of total light reflected on a scale ranging from 0 = black to 100 = white. The a* (red/green) value is a measure of the red (positive values) and green (negative values) colors of a sample. As the value of a* increases, the sample has an increase in red coloration. As the value of a* decreases the sample has an increase in green coloration. The b* (blue/yellow) value is a measure of the yellow (positive values) and blue (negative values) colors of a sample. As the value of b* increases, the sample takes on a more yellow coloration. As the value of b* decreases the sample takes on more of a blue coloration. Steaks were cut from the short loin portion of each animal, and analyzed for color. The objective color values were obtained at the central, medial, and lateral areas of the exposed longissimus at the 12th rib, and a mean value of the three locations was calculated.

Warner Bratzler Shear Analysis

After the postmortem aging period, steaks were frozen at -40°C then transferred to a -20°C holding freezer until Warner Bratzler Shear (WBS) analyses were conducted. Loin steaks were thawed for 18 hours at 2 to 4°C then broiled on Faberware (Farberware,

Bronx, NY) open-hearth broilers to an internal temperature of 71°C (American Meat Science Association, 1995). The housing and drip pans of each broiler were covered with aluminum foil and preheated for 15 min. Copper-constantan thermocouples (Omega Engineering, Inc., Stamford, CT) attached to a potentiometer were placed in the approximate geometric center of each steak and used to record internal temperature. Steaks were turned when the internal temperature of 35°C was reached and removed from the broiler when the internal temperature reached 71°C. Samples were allowed to cool at 2 to 4°C for approximately 18 hours and then 4 to 6 1.27-cm cores were removed from each steak, parallel to fiber orientation, for WBS shear force determination. Shear force determinations were conducted on an Instron (Instron Corporation, Canton, MA, Model 1011) universal testing machine equipped with a WBS head, with a crosshead speed of 200 mm/min.

pH

The pH of the steaks was measured by using an Accumet Basic pH meter (Fisher Scientific, Pittsburgh, PA 15238 Model AB15). The pH probe was standardized using standard buffer solutions of pH 4.0 and pH 7.0. A 10-g sample was taken from each steak (one steak per animal id) and placed into a stomacher bag along with 100 ml of distilled water and gently massaged by hand for one min. The pH was then recorded. The probe was rinsed with distilled water, and blotted dry with a Kim wipe (Kimberly-Clark Corporation, Roswell, GA, Cat no. 06-666) between each sample measurement.

Data Analysis

The statistical analysis for this study was performed using SAS for Windows (SAS Institute, 1998). Two experiments were conducted and both utilized a complete

randomized design. Both experiments had three treatments and ten animals per treatment. A total of 60 animals (30 per experiment) were used in this study. Analysis of variance was performed using a PROC mixed procedure of SAS to analyze cattle average daily gain, total aerobic bacteria, generic *E. coli*, fecal coliforms, total blood chemistry, and parasites. A repeated measures design was used to investigate the effects of treatment (diet) and time (month) and the interaction of treatment and time. Comparisons among means were performed using least square means (lsmeans statement) of SAS. Treatment effects and differences were considered significant when $P \leq 0.05$. Analysis of variance was performed to analyze animal feed samples, animal drinking water samples, bahiagrass samples, carcass data, objective measurements (color, pH, Warner-Bratzler Shear Force), and sensory panel evaluation in both experiments using the general linear models procedure (PROC GLM) and least square means (lsmeans) of SAS (SAS Institute, 1998). Treatment effects and differences were considered significant when $P \leq 0.05$.

RESULTS AND DISCUSSION

The objectives of this study were (1) to monitor the performance of Florida Brangus beef cattle fed three different diets that could be utilized by small farmers, (2) to monitor the prevalence of *E. coli* O157:H7, generic *E. coli*, fecal coliforms, total aerobic bacteria, and parasites in the cattle when subjected to a comprehensive feeding and optimized management program, (3) to monitor the effects of the program on dressing percentage and subjective and objective consumer parameters, and 4) to determine the microbiology and proximates of the concentrates and bahiagrass fed to the cattle. The study included two experiments.

Experiment One: Performance, Microbiology, Sensory and Objective Analyses for 17 Month Old Brangus Cattle and Environmental Sample Analyses

Growth Performance

Initial weights of the cattle were taken at the end of June 2002. Average daily gains were calculated beginning in July (month 0). The initial starting weights of all cattle were similar ($P > 0.05$) (Table 1). Feeding cattle B-80 concentrate for 28 days resulted in an increase in average daily weight gain during the first month when compared to cattle fed Super 12 concentrate and cattle allowed to graze only. After two months, the cattle fed the B-80 experienced a significant decline in average daily weight gain which resulted in all the cattle having a similar ($P > 0.05$) average daily weight gain. After 3 and 4 months, the cattle that were fed the Super 12 concentrate had significantly higher ($P < 0.05$) average daily gain when compared to cattle fed B-80 concentrate and cattle allowed to

graze only. After two months the cattle fed B-80 concentrate and the cattle allowed to graze only had similar ($P > 0.05$) average daily weight gain.

Table 1. Average daily weight gain values of Brangus steers fed different commercially available feed concentrates, and allowed to graze on bahiagrass or allowed to graze only for four months: Experiment One.

Treatment	Average Daily Weight Gain (kg)					
		Month				
	Initial Weight (kg)[a]	0[h]	1	2	3	4
Super 12[b]	345.1[x]	1.0[ye]	0.7[xe]	0.7[xe]	0.8[xe]	0.8[xe]
B-80[c]	348.3[x]	2.9[xe]	1.1[xf]	0.6[xg]	0.4[yg]	0.4[yg]
Grazers[d]	342.1[x]	1.2[ye]	0.8[xf]	0.5[xef]	0.3[yg]	0.4[yg]

[a]cattle initial weight
[b]Super 12 consisted of 10 steers given F-R-M Super 12 concentrate and allowed to graze on bahiagrass.
[c]B-80 consisted of 10 steers given B-80 concentrate with "lasalocid" and allowed to graze on bahiagrass.
[d]Grazers consisted of 10 steers allowed to graze on bahiagrass only.
[e-g]means in the same row with different superscripts differ significantly ($P \leq 0.05$).
[h]first month of steers on respective diets
[x-y]means in the same column with different superscripts differ significantly ($P \leq 0.05$).

Sollenberger et al. (1988) reported that Brangus steer gains on bahiagrass averaged 0.4 kg/day over a 2-year trial. They also reported that average daily weight gains on bahiagrass were greatest in the spring and early summer and generally declined over the remainder of the grazing season. Similar to previous reports (Sollenberger et al., 1988; Sollenberger et al., 1989) the ADG in this study generally declined throughout the experiment. Previous reports (Martin et al., 1984; Kiser et al., 1985) regarding the influence of lasalocid on beef cattle performance have been contradictory. Kiser et al. (1985) found that 200-mg lasalocid/head/d enhanced weight gain of cows fed sorghum silage, and Martin et al. (1984) reported that 200-mg lasalocid added to a corn silage diet

increased rate and efficiency of gain. In contrast, no performance response was seen when 200 mg lasalocid/d was fed in a grain carrier to fall-calving beef cows (Hopman and Weber, 1986), or when lasalocid was added to protein-supplemented corn silage diets fed to growing animals (Berger et al., 1981; Horton and Brandt, 1981). In the current study where the B-80 concentrate containing lasalocid was fed in a cottonseed, corn, and soybean meal-based formulation, the results agreed with those of Horton and Brandt, (1981). Feeding lasalocid improved average daily weight gain when compared to grazing alone. However, no advantage in average daily gain was observed for cattle fed B-80 when compared to cattle fed Super 12.

The significant treatment*month interaction ($P = 0.0001$) determined for average daily weight gain was due to the significant decreases in the cattle average daily weight gain in months 3 and 4 for cattle fed B-80 and allowed to graze only. Cattle fed Super 12 did not experience a significant decline in average daily weight gain (Table 1). After 3 and 4 months cattle fed Super 12 concentrate had significantly higher ($P < 0.05$) average daily weight gain when compared to cattle fed B-80 concentrate, and cattle allowed to graze only (Table 1).

The cattle that were fed Super 12 concentrate and allowed to graze reached the target weight of 453 ± 22 kg after four months which was approximately two months faster than the cattle fed B-80 and allowed to graze, or cattle that were allowed to graze only. All cattle that reached the target weight range, were weighed and transported to a local meat processing plant for harvesting. A total of 14 cattle (6 from the Super 12 treatment, 5 from the B-80 treatment and 3 from the grazers treatment) were harvested.

The remaining cattle (i.e. 16 animals) were placed on the Super 12 concentrate and allowed to graze until the target weight was reached.

Table 2. Average daily weight gain values of Brangus steers that were initially fed Super 12, or B-80 and allowed to graze, or allowed to graze only and then placed onto Super 12 concentrate: Experiment One.

	Average Daily Gain (kg)		
	Month		
Treatment	5[a]	6	Final Weight (kg)[g]
Super 12[b]	0.7[xe]	0.5[xe]	460.8[x]
Super 12 (B-80)[c]	0.5[ye]	0.5[xe]	445.8[y]
Super 12 (Grazers)[d]	0.4[ye]	0.5[xe]	436.8[y]

[a]remaining animals placed on Super 12 and allowed to graze.
[b]Super 12 consisted of 4 steers placed on Super 12 and allowed to graze on bahiagrass.
[c]Super 12 (B-80) consisted of 5 steers fed B-80 concentrate and allowed to graze on bahiagrass until month 5 at which time they were removed from B-80 and fed Super 12 and allowed to graze.
[d]Super 12 (Grazers) consisted of 7 steers allowed to graze on bahiagrass only until month 5 at which time they were fed Super 12 concentrate and allowed to graze.
[e]means in the same row with different superscripts differ significantly ($P \leq 0.05$).
[g]final weight of animals before slaughter.
[x-z]means in the same column with different superscripts differ significantly ($P \leq 0.05$).

After two months on Super 12, all cattle had similar ($P > 0.05$) average daily gains. Cattle that were initially on B-80 and cattle that were initially allowed to graze only did not experience a significant increase or decrease in average daily weight gain after being placed on Super 12 (Table 2). However, cattle that were initially given B-80 and allowed to graze and the cattle that were allowed to graze only reached the target weight range within an additional 2 months after being fed the Super 12. Overall the cattle that were fed the Super 12 initially had a higher ($P < 0.05$) final weight when compared to the cattle that were initially fed B-80 and allowed to graze only. One reason for this difference is

due to the fact that the steers fed B-80 and the steers allowed to graze only began with similar ($P > 0.05$) initial weights as cattle fed Super 12 throughout the study but had lower average daily weight gains.

Martz et al. (1999) reported that steers on grass-legume pastures (consisting of mostly tall fescue and Kentucky Bluegrass and red clover, white clover and birdsfoot trefoil) required more days, 40 to 88, to reach a finished weight (1200 lbs) than feedlot steers. Their findings were similar to previous research (Davies, 1977; Turner and Raleigh, 1977) wherein cattle finished on pasture had equivalent final weights to feedlot cattle with 40 to 60 additional finishing days on high quality pasture either with pasture alone or with full feeding of grain on pasture.

Microbiology of Fecal Samples

A significant treatment*month interaction ($P = 0.0001$) was revealed for total aerobic bacteria counts. This significant interaction was due to the decrease in aerobic bacteria over time (Table 3). In general the three treatments had similar ($P > 0.05$) total aerobic bacteria counts across the sampling period with the exception of a decrease and then an increase during the last two sample periods (months 3 and 4), respectively (Table 3).

Initially, the cattle that received the Super 12 concentrate had significantly lower ($P < 0.05$) aerobic bacteria counts than cattle fed B-80, or were allowed to graze only (Table 3). During the next two months (months 1 and 2) Super 12 fed cattle were similar ($P > 0.05$) in total aerobic bacteria counts when compared to cattle fed B-80 and cattle allowed to graze only. Cattle allowed to graze only were significantly lower ($P < 0.05$) in total aerobic bacteria when compared to cattle fed B-80 (Table 3).

Table 3. Mean total aerobic bacteria counts of steer fecal samples. Steers were given two different commercially available feeds and allowed to graze on bahiagrass or allowed to graze only: Experiment One.

Treatment	$\log_{10}$ CFU/g					
	Month					
	0[a]	1	2	3	4	Overall mean
Super 12[b]	7.3^{yf}	7.0^{xyf}	7.2^{xyf}	6.3^{yg}	8.3^{ye}	7.2^{y}
B-80[c]	7.6^{xf}	7.3^{xg}	7.6^{xf}	6.8^{xh}	8.2^{ye}	7.5^{x}
Grazers[d]	7.8^{xf}	6.7^{yg}	7.1^{yg}	6.6^{xg}	8.9^{xe}	7.4^{x}
Overall mean	7.5^{f}	7.0^{h}	7.3^{g}	6.6^{i}	8.4^{e}	

[a]initial month samples taken (July)
[b]Super 12 consisted of 10 steers given Super 12 concentrate and allowed to graze on bahiagrass.
[c]B-80 consisted of 10 steers given B-80 concentrate with "lasalocid" and allowed to graze on bahiagrass.
[d]Grazers consisted of 10 steers allowed to graze on bahiagrass only.
[e-i]means in the same row with different superscripts differ significantly ($P \leq 0.05$).
[x-y]means in the same column with different superscripts differ significantly ($P \leq 0.05$).

Over the next month (month 3) the cattle fed the Super 12 had significantly ($P < 0.05$) lower total aerobic bacteria counts than the cattle fed B-80 or cattle allowed to graze only. Aerobic bacteria counts were similar ($P > 0.05$) for the cattle fed B-80 and the cattle allowed to graze only (Table 3). During month 4, the grazers group had significantly higher ($P < 0.05$) total aerobic bacteria counts than the cattle fed B-80 and Super 12. The cattle that were fed Super 12 and B-80 had similar ($P > 0.05$) total aerobic bacteria counts (Table 3).

Generic *E. coli*, *E. coli* O157:H7, and *Salmonella* spp.

Initially, the cattle in all treatments had similar ($P > 0.05$) generic *E. coli* (Table 4). During months 1, 2 and 3, the Super 12 concentrate group had significantly higher ($P > 0.05$) generic *E. coli* counts when compared to the grazers (Table 4). The animals that

were fed the B-80 medicated concentrate were similar (P > 0.05) to the animals that received the Super 12 concentrate during months 1, 2 and 3. After month 4, all treatments were similar (P > 0.05) in generic *E. coli* counts (Table 4).

Table 4. Mean generic *Escherichia coli* counts of steer fecal samples. Steers were given two different commercially available feeds and allowed to graze on bahiagrass or allowed to graze only: Experiment One.

Treatment	$\log_{10}$ CFU/g					
	Month					
	0[a]	1	2	3	4	Overall mean
Super 12[b]	3.9^{xg}	4.2^{xg}	4.3^{xg}	6.2^{xf}	7.8^{xe}	5.3^{x}
B-80[c]	3.2^{xg}	3.2^{xyg}	3.8^{xyg}	6.2^{xf}	7.9^{xe}	4.7^{y}
Grazers[d]	3.6^{xg}	3.0^{yg}	3.4^{yg}	5.5^{yf}	7.9^{xe}	4.7^{y}
Overall mean	3.5^{g}	3.5^{g}	3.8^{g}	6.1^{f}	7.9^{e}	

[a]initial month samples taken (July)
[b]Super 12 consisted of 10 steers given Super 12 concentrate and allowed to graze on bahiagrass.
[c]B-80 consisted of 10 steers given B-80 concentrate with "lasalocid" and allowed to graze on bahiagrass.
[d]Grazers consisted of 10 steers allowed to graze on bahiagrass only.
[e-g]means in the same row with different superscripts differ significantly (P ≤ 0.05).
[x-y]means in the same column with different superscripts differ significantly (P ≤ 0.05).

The highest level of generic *E. coli* was observed during months 3 and 4 (October and November respectively) (Table 4). Callaway et al. (2003) discussed peak fecal shedding of generic *E. coli* and concluded that peak fecal *E. coli* shedding occurs more frequently during the summer and late fall months. The data in the current study follow that same pattern. No significant treatment*month interaction (P = 0.1779) was revealed for generic *E. coli*. In general generic *E. coli* increased as time increased. All fecal samples collected for all cattle were negative for *E. coli* O157:H7 and *Salmonella* spp.

Several researchers (Diez-Gonzalez et al., 1998; Scott et al., 2000; Krause et al., 2003) have observed an increase in *E. coli* when cattle consume high-grain diets, while others have demonstrated that high-grain diets result in decreased shedding (Hovde et al., 1999). Diez-Gonzalez et al. (1998) reported that cattle fed a 90% corn/soybean meal ration (feedlot-type ration) contained generic *E. coli* populations that were 100-fold higher than cattle fed a 100% good-quality hay (Timothy) diet. The *E. coli* recovered from the feces of grain-fed cattle were 1000-fold more resistant to an "extreme" acid shock that simulated passage through the human stomach than were *E. coli* from cattle fed only hay (Diez-Gonzalez et al., 1998). Diez-Gonzalez et al. (1998) suggested that the acidic conditions within the animal resulting from the feeding of high-grain diets, allows a population of acid resistant *E. coli* to proliferate. Acid resistant *E. coli* would in turn survive the acidic conditions in the human gastric stomach and result in an increased risk of human infection (Diez-Gonzalez et al., 1998). The results of the current study agree with those of Diez-Gonzalez et al. (1998) in that an increase in generic *E. coli* populations was observed in the cattle fed Super 12 when compared to cattle that were allowed to graze only. However that was not true with cattle fed B-80 when compared to cattle allowed to graze only. In contrast Hovde et al. (1999) found no significant differences in *E. coli* present in experimentally infected cattle fed high-grain or high-fiber diets.

Hancock et al. (1997) examined 36 beef cattle herds between Idaho, Oregon, and Washington (12 in each state). Their research showed a range of 0% to 5.5% herd prevalence for *E. coli* O157:H7, with a strong clustering toward the lower end of this range. It has been reported that weaned dairy cattle and yearling beef cattle at slaughter

are more likely to shed *E. coli* O157:H7 in their feces than adult cattle (Buchko et al., 2000).

Microbiology for Bahiagrass

The mean total aerobic bacteria counts for the bahiagrass samples were similar ($P > 0.05$) in months 0 and 4 (July and November respectively) (Table 5). The total aerobic bacteria counts for all grass samples were approximately 6 $\log_{10}$ CFU/g. *E. coli, E. coli* O157:H7, fecal coliforms, and *Salmonella* spp. were not detected on any of the grass samples.

Microbiology for Animal Drinking Water

The mean total aerobic bacteria counts for the animal drinking water samples were similar ($P > 0.05$) for all treatments in months 0 and 4 (July and November respectively) (Table 6). Total aerobic bacteria counts were approximately 3.0 $\log_{10}$ CFU/ml for all treatments. The mean counts for generic *E. coli* and fecal coliforms were also similar ($P > 0.05$) for all treatments, and were less than 1.0 $\log_{10}$ CFU/ml, and 2.0 $\log_{10}$ CFU/ml respectively. No *E. coli* O157:H7 or *Salmonella spp.* was detected in any of the drinking water samples. *E. coli* O157:H7 can persist in water trough sediments for periods of at least 4 months and may even be able to replicate in this environment (Hancock et al., 1997).

Microbiology for Animal Feed

The mean total aerobic bacteria counts for the Super 12 and the B-80 medicated feeds were similar ($P > 0.05$) (Table 7). *E. coli, E. coli* O157:H7, *Salmonella,* and fecal coliforms were not detected in any of the two feeds during the month 0 and 4 (July and November respectively).

Table 5. Mean total aerobic bacterial counts of bahiagrass that was grazed by all three groups of steers for Experiment One.

	(log_{10} CFU/g)		
	Month		
Treatment	0	4	Mean
Super 12[a]	6.1^{xd}	6.0^{xd}	6.0^{x}
B-80[b]	5.7^{xd}	5.8^{xd}	5.8^{x}
Grazers[c]	6.1^{xd}	6.1^{xd}	6.1^{x}

[a]Super 12 consisted of 10 steers given Super 12 concentrate and allowed to graze on bahiagrass.
[b]B-80 consisted of 10 steers given B-80 concentrate with "lasalocid" and allowed to graze on bahiagrass.
[c]Grazers consisted of 10 steers allowed to graze on bahiagrass only.
[d]means in the same row with different superscripts differ significantly ($P \leq 0.05$).
[x]means in the same column with different superscripts differ significantly ($P \leq 0.05$).

Table 6. Mean total aerobic bacteria counts, *Escherichia coli*, and Fecal coliform counts for the animal drinking water for Experiment One.

	total aerobic bacteria (log_{10} CFU/ml)			*E. coli* (log_{10} CFU/ml)			Fecal coliforms (log_{10} CFU/ml)		
	Month								
Treatment	0	4	Mean	0	4	Mean	0	4	Mean
Super 12[a]	3.1^{xd}	3.2^{xd}	3.2^{x}	1.0^{xd}	0.8^{xd}	0.9^{x}	1.9^{xd}	1.8^{xd}	1.8^{x}
B-80[b]	2.8^{xd}	3.0^{xd}	2.9^{x}	0.3^{xd}	0.5^{xd}	0.3^{x}	1.5^{xd}	1.6^{xd}	1.5^{x}
Grazers[c]	2.7^{xd}	2.9^{xd}	2.8^{x}	0.6^{xd}	0.4^{xd}	0.5^{x}	1.8^{xd}	1.8^{xd}	1.8^{x}

[a]Super 12 consisted of 10 steers given Super 12 concentrate and allowed to graze on bahiagrass.
[b]B-80 consisted of 10 steers given B-80 concentrate with "lasalocid" and allowed to graze on bahiagrass.
[c]Grazers consisted of 10 steers allowed to graze on bahiagrass only.
[d]means in the same row with different superscripts differ significantly ($P \leq 0.05$).
[x]means in the same column with different superscripts differ significantly ($P \leq 0.05$).

Table 7. Mean total aerobic bacterial counts of the two commercially available animal feeds given to the steers for Experiment One.

	(log10 CFU/g)		
	Month		
Feed Concentrates	0	4	Mean
F-R-M Super 12[a]	4.5^{xc}	4.6^{xc}	4.6^{x}
B-80 Medicated[b]	5.6^{xc}	5.7^{xc}	5.6^{x}

[a]Super 12 concentrate fed to 10 animals in addition to grazing on bahiagrass.
[b]B-80 concentrate containing lasalocid and fed to 10 animals in addition to grazing on bahiagrass.
[c]means in the same row with different superscripts differ significantly ($P \leq 0.05$).
[x]means in the same column with different superscripts differ significantly ($P \leq 0.05$).

Parasites

Coccidia are protozoan parasites chiefly of the genus *Eimeria*. Coccidia destroy the epithelial cells of the intestine and impair the absorption of nutrients. A significantly higher ($P < 0.05$) count for coccidia eggs was determined in the animals that were allowed to graze on bahiagrass only, when compared to cattle fed Super 12 and B-80 (Table 8). Cattle fed Super 12 and B-80 concentrates had similar ($P > 0.05$) levels of coccidia eggs (Table 8). However, a lower number of coccidia were isolated from the cattle fed B-80 concentrate when compared to Super 12 and cattle allowed to graze only. A possible explanation for this is the fact that the B-80 concentrate contained lasalocid which is used as a coccidiostat. Diet regimen had no effect on the level of the *Haemonchus* or *Moniezia* eggs isolated from the three treatment groups (Table 8).

Haemonchus thrives under Florida weather conditions, and is a potential year round threat. During the summer months the eggs hatch readily in the warm, humid and rainy climate, releasing viable larvae into the environment. This is the time of greatest

Table 8. Mean parasitic eggs isolated from feces of steers given two different commercially available feeds and allowed to graze on bahiagrass or allowed to graze only: Experiment One.

Treatment	Coccidia (EPG)	*Haemonchus* (EPG)	*Moniezia* (EPG)
Super 12[a]	8.38[y]	1.37[x]	0.29[x]
B-80[b]	3.66[y]	1.15[x]	0.15[x]
Grazers[c]	18.28[x]	1.80[x]	0.00[x]

[a] Super 12 consisted of 10 steers given Super 12 concentrate and allowed to graze on bahiagrass.
[b]B-80 consisted of 10 steers given B-80 concentrate with "lasalocid" and allowed to graze on bahiagrass.
[c]Grazers consisted of 10 steers allowed to graze on bahiagrass only.
[x-y]means in the same column with different superscripts differ significantly ($P \leq 0.05$).

exposure and highest incidence of disease. During the cooler weather of winter months larvae have developed the ability to "hibernate". This process is called hypobiosis. During this time the worms are metabolically very inactive and quite resistant to treatment. In the spring the dormant worms become active again, resulting in a "spring rise" in the number of eggs excreted, and a seeding of the environment just before optimal summer conditions occur (Heath and Harris, 1991).

Bahiagrass Samples

Moisture, ash, fat, protein, pH and crude fiber of the grass samples were similar ($P > 0.05$) for all plots of grass grazed by the animals (Table 9). Protein percentage of any grass sample depends on the maturity of the grass, and whether grass has been fertilized. Kalmbacher and Wade (2003) reported a crude protein value of 12-15% for fertilized bahiagrass and a value of 9-12% for unfertilized bahiagrass. The protein values in this study are in agreement with those reported by Kalmbacher and Wade (2003).

Table 9. Mean proximate analysis values and pH for bahiagrass samples collected from pastures for Experiment One.

	Bahiagrass					
Treatment	Super 12[a]		B-80[b]		Grazers[c]	
	Month 0[e]	Month 4[f]	Month 0	Month 4	Month 0	Month 4
Moisture, %	52.6[d]	50.7[d]	51.3[d]	50.6[d]	52.8[d]	50.5[d]
Ash[g], %	5.5[d]	5.6[d]	4.9[d]	5.5[d]	5.1[d]	5.3[d]
Fat[g], %	2.4[d]	2.6[d]	2.8[d]	2.5[d]	2.4[d]	2.2[d]
Protein[g], %	15.8[d]	7.2[d]	14.2[d]	7.4[d]	14.1[d]	7.7[d]
Crude fiber, %	23.7[d]	33.9[d]	26.8[d]	34.0[d]	25.6[d]	34.3[d]
pH	6.7[d]	6.7[d]	6.5[d]	6.6[d]	6.8[d]	6.6[d]

[a]Super 12 consisted of 10 steers given Super 12 concentrate and allowed to graze on bahiagrass.
[b]B-80 consisted of 10 steers given B-80 concentrate with "lasalocid" and allowed to graze on bahiagrass.
[c]Grazers consisted of 10 steers allowed to graze on bahiagrass only.
[d]means in the same row with different superscripts differ significantly ($P \leq 0.05$).
[e]June 2002
[f]June 2004
[g]values expressed on a dry matter basis

Cattle Blood Samples

Aspartate amino transferase (AST) is an enzyme that promotes transfer of an amino group from glutamic acid to oxaloacetic acid. Gamma glutamyl transpeptidase (GGT) is an enzyme that participates in the transfer of amino acids across the cellular membrane. They both can be measured in the blood to test liver function. Significantly higher ($P < 0.05$) amounts of AST, and GGT were found in the cattle that were fed the Super 12 concentrate when compared to cattle allowed to graze only, and cattle fed B-80 (Table 10). The cattle that were fed B-80 and the cattle that were allowed to graze only were similar ($P > 0.05$) for AST and GGT. Although there were significantly higher amounts

detected in this group they were not high enough to indicate severe liver disease (Osweiler et al., 1993). Although there was a higher amount of AST and GGT detected in the blood of the cattle that were fed the Super 12 concentrate, the values detected in the blood of all animals regardless of diet were within the expected range of 46-185 U/L, and 11-60 U/L for AST and GTT, respectively.

There was a significantly higher ($P < 0.05$) amount of calcium detected in the cattle that were fed the B-80 concentrate when compared to the cattle that were fed the Super 12 and the cattle that were allowed to graze only. A similar ($P > 0.05$) amount of calcium was detected in the blood of the cattle that were fed the Super 12 concentrate and the cattle that were allowed to graze only (Table 11).

Table 10. Mean blood values of aspartate amino transferase and gamma glutamyl transpeptidase in the blood of steers given two different commercially available feeds and allowed to graze on bahiagrass or allowed to graze only for Experiment One.

Treatment	AST (U/L)[d]	GGT (U/L)[d]
Super 12[a]	96.3[x]	21.1[x]
B-80[b]	75.5[y]	12.0[y]
Grazers[c]	74.3[y]	13.4[y]

[a]Super 12 consisted of 10 steers given Super 12 concentrate and allowed to graze on bahiagrass.
[b]B-80 consisted of 10 steers given B-80 concentrate with "lasalocid" and allowed to graze on bahiagrass.
[c]Grazers consisted of 10 steers allowed to graze on bahiagrass only.
[d]AST = Asparate Amino Transferase
[e]GGT = Gamma glutamyl transpeptidase
[x-y]means in the same column with different superscripts differ significantly ($P \leq 0.05$).

Although there was a significantly higher amount of calcium detected in the cattle that were fed the B-80, the level of calcium in the blood of all cattle was within the expected range of 8.1-11.0 mg/dL. Calcium (Ca) and phosphorus (P) has a vital function

in almost all tissues in the body and must be available to livestock in the proper quantities and ratio. These elements make up over 70% of the total mineral elements in the body (McDowell and Arthington, 2005). Ninety-nine percent of the Ca and 80% of the P in the entire body are found in bones and teeth. Adequate Ca and P nutrition depends not only on sufficient total dietary supplies, but also on the chemical form in which they occur in the diet and on the vitamin D status of the animal. The dietary Ca:P ratio also can be important. A dietary Ca:P ratio between 1:1 and 2:1 is assumed to be ideal for growth and bone formation as this is approximately the ratio of the two minerals in bone. Ruminants can tolerate a wider range of Ca:P particularly when their vitamin D status is high. Clinical signs of borderline Ca deficiencies are not easily distinguishable from other deficiencies. An inadequate intake of Ca may cause weakened bones, slow growth, low milk production in dairy cattle and tetany (convulsions) in severe deficiencies (Williams et al., 1990; McDowell and Arthington, 2005).

Table 11. Mean blood values for calcium, magnesium, chloride and potassium in the blood of steers given two different commercially available feeds and allowed to graze on bahiagrass or allowed to graze only for Experiment One.

Treatment	Calcium (mg/dL)	Magnesium (mg/dL)	Chloride (mEq/L)	Potassium (mEq/L)
Super 12[a]	8.9[y]	2.1[x]	106.6[x]	4.6[y]
B-80[b]	9.5[x]	1.8[y]	107.5[x]	5.0[x]
Grazers[c]	8.9[y]	2.1[x]	102.9[y]	4.5[y]

[a]Super 12 consisted of 10 steers given Super 12 concentrate and allowed to graze on bahiagrass.
[b]B-80 consisted of 10 steers given B-80 concentrate with "lasalocid" and allowed to graze on bahiagrass.
[c]Grazers consisted of 10 steers allowed to graze on bahiagrass only.
[x-y]means in the same column with different superscripts differ significantly ($P \leq 0.05$).

A significantly lower ($P < 0.05$) amount of magnesium was detected in the cattle that were fed the B-80 concentrate when compared to the cattle that were fed the Super 12 concentrate and the cattle that were allowed to graze only (Table 11). A similar amount of magnesium was detected in the blood of the cattle that were fed the Super 12 concentrate and the cattle that were allowed to graze only. However, the level of magnesium in all cattle was within the expected range of 1.8-3.0 mg/dL. Magnesium (Mg) has many diverse physiological functions. The Mg in the skeleton is important for the integrity of bones and teeth. Magnesium is the second most plentiful cation (after Potassium) of intracellular fluids. Deficiency of Mg in cattle can lead to hypomagnesemic tetany (convulsions) which can be classified into clinical and non-clinical tetany (McDowell and Arthington, 2005).

A significantly lower ($P < 0.05$) amount of chloride (Cl) was detected in the blood of the cattle that were allowed to graze only when compared to cattle fed the concentrates (Table 11). The concentration of chloride was similar ($P > 0.05$) for cattle that were fed the Super 12 and B-80 concentrates. Although there were differences in chloride detected between the groups, the level of chloride for all cattle was within the expected range of 99-110 mEq/L. Sodium and chloride, in addition to potassium, all function in maintaining osmotic pressure and regulating acid-base equilibrium. These two mineral elements function as electrolytes in body fluids and are specifically involved at the cellular level in water metabolism, nutrient uptake, and transmission of nerve impulses. Chlorine is necessary for activation of amylase and is essential for formation of gastric hydrochloric acid (McDowell and Arthington, 2005). The essential need for sodium (Na) and Cl by livestock has been demonstrated for thousands of years by a natural craving for

common salt. Sodium is the critical nutrient in salt and evidence of a naturally occurring dietary deficiency of Cl, as distinct from Na, has not been established. However, the requirement is often expressed as salt (NaCl) (McDowell and Arthington, 2005). The Na requirement for ruminants is between 0.04% and 0.25% of the diet. The Cl requirement for ruminants is generally unknown. Fettman et al. (1984) estimated a Cl requirement for lactating dairy cows to be between 0.10% and 0.20% and would not exceed 0.27%.

The initial sign of Na deficiency is a craving for salt, demonstrated by the avid licking of wood, soil, and sweat from other animals and drinking water. Cattle deprived of salt may be so voracious that they often injure each other in attempting to reach salt. A prolonged deficiency causes loss of appetite, decreased growth, unthrifty appearance, reduced milk production, and loss of weight. More pronounced signs of Na deficiencies include shivering, incoordination, weakness, and cardiac arrhythmia, which can lead to death (McDowell and Arthington, 2005). Coppock (1986) reported that an experimentally produced Cl deficiency, independent of Na deficiency, results in clinical signs in dairy cows that include decreased body weight and milk production, depraved appetite, lethargy, anorexia, emaciation, constipation, cardiovascular depression, and milk dehydration.

A significantly higher ($P < 0.05$) amount of potassium was detected in the blood of the cattle that were fed the B-80 concentrate when compared to the cattle that were fed the Super 12 and the cattle that were allowed to graze only (Table 11). The concentration of potassium was similar ($P > 0.05$) for cattle that were fed the Super 12 concentrate and the cattle that were allowed to graze only (Table 11). Although there was a significantly higher amount of potassium detected in the cattle that were fed B-80, the level of

potassium for all cattle was within the expected range of 4.0-5.5 mEq/L. Potassium is the third most abundant mineral element in the animal body and is the principal cation of intracellular fluid. It also is a constituent of extracellular fluid where it influences muscle activity. Potassium is essential for life, being required for a variety of body functions including osmotic balance, acid-base equilibrium, several enzyme systems and water balance. Potassium deficiency for ruminants results in non-specific signs such as slow growth, reduced feed and water intake, lowered feed efficiency, muscular weakness, nervous disorders, stiffness, decreased pliability of hide, emaciation, intracellular acidosis, and degeneration of vital organs (McDowell and Arthington, 2005).

There was a significantly higher ($P < 0.05$) anion gap (acid/base balance) in the cattle that were fed Super 12 concentrate when compared to the cattle that were fed the B-80 and the cattle that were allowed to graze only (Table 12). The anion gap was similar ($P > 0.05$) for cattle that were fed B-80 concentrate and cattle that were allowed to graze only (Table 12). Despite the higher anion gap in the Super 12 cattle, all three groups of cattle were within the expected anion gap range of 10-30.

There was a significantly higher ($P < 0.05$) concentration of glucose detected in the blood of the cattle that were fed the Super 12 concentrate when compared to the cattle fed the B-80 and the cattle that were allowed to graze only (Table 12). A similar ($P > 0.05$) amount of glucose was detected in the blood of the cattle fed B-80 and the cattle that were allowed to graze only (Table 12). Despite the differences in glucose levels detected within the blood, all glucose levels regardless of diet regimen were within the expected range for glucose of 40-80 mg/dL.

A significantly higher ($P < 0.05$) amount of carbon dioxide was detected in the blood of cattle that were allowed to graze only when compared to the cattle that were fed the B-80 and Super 12 concentrates (Table 12). The cattle that were fed the Super 12 and B-80 concentrates had similar ($P > 0.05$) levels of carbon dioxide detected in their blood. All cattle's carbon dioxide levels regardless of diet regimen were within the expected range for carbon dioxide of 15-34 mEq/L.

Table 12. Mean blood values for anion gap, glucose, and carbon dioxide in the blood of steers given two different commercially available feeds and allowed to graze on bahiagrass or allowed to graze only for Experiment One.

Treatment	anion gap	glucose (mg/dL)	carbon dioxide (mEq/L)
Super 12[a]	18.8^{x}	75.8^{x}	21.3^{y}
B-80[b]	16.6^{y}	69.7^{y}	21.3^{y}
Grazers[c]	17.2^{y}	70.5^{y}	24.3^{x}

[a]Super 12 consisted of 10 steers given Super 12 concentrate and allowed to graze on bahiagrass.
[b]B-80 consisted of 10 steers given B-80 concentrate with "lasalocid" and allowed to graze on bahiagrass.
[c]Grazers consisted of 10 steers allowed to graze on bahiagrass only.
[x-y]means in the same column with different superscripts differ significantly ($P \leq 0.05$).

Carcass

The cattle that were fed the Super 12 concentrate had a significantly higher ($P < 0.05$) carcass weight when compared to the cattle that were allowed to graze only (Table 13). The cattle that were fed B-80 concentrate had similar carcass weight ($P > 0.05$) when compared to cattle fed Super 12 concentrate and cattle that were allowed to graze only (Table 13). The significantly higher ($P < 0.05$) carcass weight observed in the cattle that were fed Super 12 when compared to the cattle that were allowed to graze only is due to the fact that cattle that were allowed to graze only had similar initial live body weight

and lower average daily gains when compared to cattle fed Super 12. The cattle fed Super 12 also had a higher final weight than did the cattle that were allowed to graze only (Table 13). The dressing percentage was similar ($P > 0.05$) for all treatments. The subjective carcass color of the lean, firmness of the lean, and texture of the lean were similar ($P > 0.05$) for all three groups of cattle (Table 13). The cattle that were fed

Table 13. Carcass characteristics and standard error of means from steers that were given two different commercially available feeds and allowed to graze on bahiagrass or allowed to graze only for Experiment One.

Trait	Super 12[a]	B-80[b]	Grazers[c]	SEM
Hot carcass weight, kg	243.7^{i}	231.7^{ij}	225.3^{j}	12.03
Dressing percent, %	52.9^{I}	52.0^{I}	51.6^{I}	-
Lean color[d]	4.1^{i}	4.1^{i}	3.4^{i}	0.57
Lean firmness[e]	2.8^{i}	2.8^{i}	2.8^{i}	0.43
Lean texture[f]	2.9^{i}	3.2^{i}	3.5^{i}	0.36
Fat thickness, cm	0.9^{i}	0.5^{j}	0.5^{j}	0.27
Ribeye area, cm^2	67.5^{i}	67.5^{i}	62.0^{i}	0.37
Marbling score[g]	Sl^{30i}	T^{90j}	Sl^{0j}	9.88
Lean maturity[h]	A^{i}	A^{i}	A^{i}	4.03

[a]Super 12 consisted of 10 steers given Super 12 concentrate and allowed to graze on bahiagrass.
[b]B-80 consisted of 10 steers given B-80 concentrate with "lasalocid" and allowed to graze on bahiagrass.
[c]Grazers consisted of 10 steers allowed to graze on bahiagrass only.
[d]1= dark pink, 2= very light cherry red, 3= light cherry red, 4= slightly light cherry red, 5= cherry red, 6= moderately dark red, 7= dark red, 8= very dark red.
[e]1= very firm, 2= firm, 3= moderately firm, 4= slightly soft, 5= soft, 6= very soft, 7= extremely soft.
[f]1= very fine, 2= fine, 3= moderately fine, 4= slightly coarse, 5= coarse, 6= very coarse, 7= extremely coarse.
[g]Sl= Slight, T= Trace
[h]A= approximate live age of 9-30 months.
[I-j]means in the same row with different superscripts differ significantly ($P \leq 0.05$).

Super 12 and B-80 concentrates were found to have a slightly light cherry red color (score of 4.1), while the animals that were allowed to graze only were found to have a light cherry red color (score of 3.4). Beef that is not a bright, attractive color is often perceived by consumers to be old, unwholesome, or from an old animal (Dikeman, 1990). Davis et al. (1981) found that there were no differences in lean color when steers were fed limited grain in order to achieve the same growth rate as pasture-fed steers. All steers in the three groups in this study were found to have moderately firm lean as measured subjectively by trained meat staff personnel. The cattle that were fed Super 12 were found to have a moderately fine texture of lean. The cattle that were fed the B-80 and the cattle that were allowed to graze only were found to have a slightly coarse texture of lean. The cattle that were fed the Super 12 had significantly higher ($P < 0.05$) fat over eye thickness, and marbling score when compared to the cattle that were fed B-80 and cattle that were allowed to graze only (Table 13). Cattle that were allowed to graze only and cattle that were fed B-80 had similar ($P > 0.05$) fat thickness, and marbling scores (Table 13). Marbling (intramuscular fat) is the intermingling or dispersion of fat within the lean. Graders evaluate the amount and distribution of marbling in the ribeye muscle at the cut surface after the carcass has been ribbed between the 12^{th} and 13^{th} ribs (Hale et al., 2005).

Muir et al. (1998) reported no significant effect of feeding regime on marbling. The ribeye area as well as the maturity for all three treatments were similar ($P > 0.05$) (Table 13). Cattle that were fed Super 12 and cattle that were allowed to graze only were found to have a slight degree of marbling. The cattle that were fed the B-80 were found to have a trace degree of marbling. All cattle were found to have A maturity or an approximate live age of less than 30 months. Maturity refers to the physiological age of

the animal rather than the chronological age. The reason is due to the fact that chronological age is almost always unknown. Indicators of maturity are bone characteristics, ossification of cartilage, color and texture of ribeye muscle. Cartilage becomes bone, lean color darkens and texture becomes coarser with increasing age (Hale et al., 2005). In A maturity carcasses, ribs are quite round and red. Redness of the ribs gradually decreases with advancing age and generally become white in color because they no longer manufacture red blood cells (Hale et al., 2005).

Objective Color Analysis

Feeding regimen did not affect objective evaluation of brightness (L* value), redness (a*), and yellowness (b*) values of the steaks (Table 14).

Table 14. Mean objective color values of Brangus steer steaks cut from the short loin portion of steers given two different commercially available feeds and allowed to graze on bahiagrass or allowed to graze only for Experiment One.

Treatment	L*	a*	b*
Super 12[a]	39.0[x]	23.7[x]	7.7[x]
B-80[b]	38.2[x]	22.9[x]	7.5[x]
Grazers[c]	37.8[x]	22.8[x]	7.2[x]

[a]Super 12 consisted of 10 steers given Super 12 concentrate and allowed to graze on bahiagrass.
[b]B-80 consisted of 10 steers given B-80 concentrate with "lasalocid" and allowed to graze on bahiagrass.
[c]Grazers consisted of 10 steers allowed to graze on bahiagrass only.
[x]means in the same column with different superscripts differ significantly ($P \leq 0.05$).
L*=0 (black) to 100 (white), a*= + (red) to - (green), b*= + (yellow) to - (blue).

The steaks from all cattle in the three treatment groups had similar ($P > 0.05$) L*, a* and b* values. A reduction in the L* value represents less brightness in a sample and more darkness. A reduction in the a* value represents less red color. Reduction in the b* value represents less yellow. Thus lower a* and b* values are typically perceived as

being darker (Reiling and Johnson, 2001). O'Sullivan et al. (2002) reported no significant effect of diet on Hunter "a" values of aerobically packaged steaks from animals that consumed maize silage, maize silage plus grass silage (perennial ryegrass), or grass silage alone.

pH

Feeding regimen had no effect on the pH of the steaks (Table 15). All steaks in all three treatments were similar ($P > 0.05$). The pH of meat has been shown to affect the ability of meat to retain water. As the pH of meat approaches the isoelectric point of the muscle proteins (5.4), the proteins lose their inherent ability to bind water and as a result water loss increases (Pringle et al., 1995). The pH of the steaks in this study were at the

Table 15. Mean pH values of Brangus steer steaks cut from the short loin portion of steers given two different commercially available feeds and allowed to graze on bahiagrass or allowed to graze only for Experiment One.

Treatment	pH
Super 12[a]	5.4[x]
B-80[b]	5.4[x]
Grazers[c]	5.4[x]

[a]Super 12 consisted of 10 steers given Super 12 concentrate and allowed to graze on bahiagrass.
[b]B-80 consisted of 10 steers given B-80 concentrate with "lasalocid" and allowed to graze on bahiagrass.
[c]Grazers consisted of 10 steers allowed to graze on bahiagrass only.
[x]means in the same column with different superscripts differ significantly ($P \leq 0.05$).

isoelectric point of muscle proteins. Pringle et al. (1995) reported pH values for strip loin and top sirloin steaks to be around 5.3-5.4 respectively.

Thaw loss/Cooking loss

Thaw loss and cooking loss were similar ($P > 0.05$) for all treatments (Table 16). The steaks from cattle that were allowed to graze only had the lowest thaw loss, followed by the steaks from the cattle that were fed the B-80 concentrate. Water is the major component of meat (comprising about 75% of the mass) and imparts many of the meat's attributes, particularly its juiciness. The term "purge" refers to the water and water-soluble proteins that are lost from meat. Weight loss due to purge is especially important to meat purveyors because it represents a loss of saleable weight. It can also cause deterioration of appearance and is a perfect medium for bacterial growth (Pringle et al., 1998).

Table 16. Mean thaw loss and cooking loss of Brangus steer steaks cut from the short loin portion of steers given two different commercially available feeds and allowed to graze on bahiagrass or allowed to graze only for Experiment One.

Treatment	Percent Thaw loss	SEM	Percent Cooking loss	SEM
Super 12[a]	4.1[x]	0.65	25.4[x]	0.77
B-80[b]	3.9[x]	0.65	24.8[x]	0.77
Grazers[c]	3.4[x]	0.65	25.0[x]	0.77

[a]Super 12 consisted of 10 steers given Super 12 concentrate and allowed to graze on bahiagrass.
[b]B-80 consisted of 10 steers given B-80 concentrate with "lasalocid" and allowed to graze on bahiagrass.
[c]Grazers consisted of 10 steers allowed to graze on bahiagrass only.
[x]means in the same column with different superscripts differ significantly ($P \leq 0.05$).

Sensory and Warner Bratzler Shear Analyses

The trained sensory panel rated the steaks in all treatments similar ($P > 0.05$) for juiciness, beef flavor, and off-flavor (Table 17). The panelists determined that steaks from cattle fed Super 12, B-80 concentrate, and allowed to graze only were all slightly

juicy. It was determined by the panelists that steaks from all cattle had a slightly intense beef flavor. The panelists determined that steaks from all cattle had a threshold, barely detected off-flavor (Table 17).

Larick et al. (1987) measured carcass characteristics and flavor of beef from steers fed corn-silage based rations for 0, 56, 84, and 112 days after being backgrounded on pasture. The researchers reported that grassy flavor was detected in all treatments, but it (grassy flavor) was minimal after 84 days on feed. In the current study, no grassy flavor was detected by the panelists. Steaks from cattle that were fed Super 12 rated significantly lower ($P < 0.05$) in overall tenderness when compared to steaks from cattle that were allowed to graze only (Table 17).

Table 17. Mean trained sensory panel scores of Brangus steer steaks cut from the short loin portion of steers given two different commercially available feeds and allowed to graze on bahiagrass or allowed to graze only for Experiment One.

Treatment	Juiciness	Beef flavor	Tenderness	Connective tissue	Off-flavor
Super 12[a]	5.4^{x}	5.5^{x}	4.9^{y}	5.2^{y}	5.1^{x}
B-80[b]	5.2^{x}	5.3^{x}	5.1^{xy}	5.5^{y}	5.2^{x}
Grazers[c]	5.2^{x}	5.4^{x}	5.5^{x}	5.9^{x}	5.4^{x}

[a]Super 12 consisted of 10 steers given Super 12 concentrate and allowed to graze on bahiagrass.
[b]B-80 consisted of 10 steers given B-80 concentrate with "lasalocid" and allowed to graze on bahiagrass.
[c]Grazers consisted of 10 steers allowed to graze on bahiagrass only.
[x-y]means in the same column with different superscripts differ significantly ($P \leq 0.05$).

Steaks from cattle fed B-80 were similar ($P > 0.05$) in overall tenderness when compared to steaks from cattle that were fed Super 12 and steaks from cattle that were allowed to graze only (Table 17). The panelists scored steaks from cattle that were

allowed to graze only "moderately tender", and steaks from cattle that were fed Super 12 and B-80 "slightly tender."

The panelists detected similar ($P > 0.05$) connective tissue in steaks from cattle that were fed Super 12 and B-80 (Table 17). The panelists reported that steaks from cattle fed B-80 and Super 12 had a "slight amount" of connective tissue." Steaks from cattle fed Super 12 and B-80 were rated significantly lower ($P < 0.05$) for connective tissue when compared to steaks from cattle allowed to graze only (Table 17). The panelists reported that steaks from cattle that were allowed to graze only had a "trace amount of connective tissue."

Table 18. Mean Warner-Bratzler Shear force values of Brangus steer steaks cut from the short loin portion of steers given two different commercially available feeds and allowed to graze on bahiagrass or allowed to graze only for Experiment One.

Treatment	Warner-Bratzler Shear Force (kg)
Super 12[a]	3.5[x]
B-80[b]	3.9[x]
Grazers[c]	3.8[x]

[a]Super 12 consisted of 10 steers given Super 12 concentrate and allowed to graze on bahiagrass.
[b]B-80 consisted of 10 steers given B-80 concentrate with "lasalocid" and allowed to graze on bahiagrass.
[c]Grazers consisted of 10 steers allowed to graze on bahiagrass only.
[x]means in the same column with different superscripts differ significantly ($P \leq 0.05$).

The major sensory difference in beef from forage-fed and grain-fed steers is flavor of the fat (Griebenow et al., 1997). The less desirable flavor of forage-fed beef has been described as intense milky-oily, sour, and fishy flavors, or a grassy flavor, and the lack of a beef-fat flavor (Griebenow et al., 1997). Simonne et al. (1996) reported no difference in sensory panel results for steaks from pasture finished steers (annual ryegrass) and beef

from grain-finished steers. There appears to be a large variation in the ability to detect off-flavors between trained taste-test panelists and consumer panelists. Trained panelists consistently detected a grassy flavor in all-forage finishing systems (Griebenow et al., (1997), whereas consumer panelists are not as likely to detect and identify a flavor as being grassy. Consumer demands for a leaner product and reduced feed-grain use calls for the identification of a feeding system that will consider these factors and still produce beef of acceptable eating quality (Griebenow et al., 1997).

All loin steaks from all three treatments were similar ($P > 0.05$) for Warner Bratzler shear values (WBS) (Table 18). Muir et al. (1998) reported no differences between WBS values for beef samples from grass- and grain-finishing systems. Shackelford et al. (1991) published the first threshold relating Warner-Bratzler shear force values to consumer data. These researchers reported that WBS values less than 3.5 kg were considered "tender," 3.6 to 4.9 were considered "acceptable tenderness," and values greater than 5.0 "tough." Applying the scale used by Shackelford et al. (1991) to the data in this study, all loin steaks in Experiment One were "acceptable tenderness."

Experiment Two: Performance, Microbiology, Sensory and Objective Analyses for 10 Month Old Brangus Cattle and Environmental Sample Analyses

Growth Performance

Initial weights of cattle were taken at the end of October 2003. The initial weights of all cattle were similar ($P > 0.05$). Average daily weight gains were calculated beginning in November 2003 (month 0). During the first two months (months 0 and 1), all cattle had similar ($P > 0.05$) average daily gain (Table 19). During month 2, cattle that were fed Super 12 concentrate had similar ($P > 0.05$) average daily gains when compared

to the cattle fed B-80 and the cattle that were allowed to graze only. The cattle that were allowed to graze only had a significantly lower ($P < 0.05$) average daily gain when compared to the cattle that were fed B-80 (Table 19). During months 3 through 7, cattle fed Super 12 had significantly ($P < 0.05$) higher average daily weight gains when compared to cattle fed B-80 and cattle allowed to graze only (Table 19). The cattle that

Table 19. Average daily weight gain values of Brangus steers fed different commercially available feed concentrates, and allowed to graze on bahiagrass or allowed to graze only for seven months: Experiment Two.

		Average Daily Gain (kg)							
		Months							
Treatment	initial weight (kg)[a]	0[h]	1	2	3	4	5	6	7
Super 12[b]	244.4[x]	-0.3[xg]	0.3[xf]	0.3[xyf]	1.0[xe]	1.0[xe]	1.0[xe]	1.0[xe]	1.0[xe]
B-80[c]	243.1[x]	-0.6[xg]	0.3[xf]	0.5[xef]	0.5[yef]	0.4[yef]	0.4[yef]	0.5[yef]	0.6[yef]
Grazers[d]	252.7[x]	-0.2[xg]	0.4[xef]	0.2[yf]	0.1[zf]	0.1[zf]	0.3[yef]	0.5[ye]	0.6[ye]

[a]cattle initial weight (kg)
[b]Super 12 consisted of 10 steers given F-R-M Super 12 concentrate and allowed to graze on bahiagrass.
[c]B-80 consisted of 10 steers given B-80 concentrate with "lasalocid" and allowed to graze on bahiagrass.
[d]Grazers consisted of 10 steers allowed to graze on bahiagrass only.
[e-g]means in the same row with different superscripts differ significantly ($P \leq 0.05$).
[h]first month of steers on respective diets.
[x-z]means in the same column with different superscripts differ significantly ($P \leq 0.05$).

were fed B-80 had significantly higher ($P < 0.05$) average daily gain than cattle that were allowed to graze only after 3 and 4 months. After month 5 and through month 7, cattle that were fed B-80 had similar ($P > 0.05$) in average daily weight gains when compared to cattle that were allowed to graze only (Table 19). Sollenberger et al. (1989) reported that when steers were rotationally grazed on bahiagrass, their average daily gain was 0.84

lbs/day over 3 growing seasons. The researchers also reported that gains on bahiagrass during mid-summer and early fall were low. These periods of low steer gain were accompanied by low forage digestibility (Sollenberger et al., 1989). Kunkle et al. (1991) reported average daily gains of 0.75 kg/day for nursing calves that were grazed on bahiagrass pastures and supplemented with cottonseed meal and an average daily gain of 0.54 kg/day for control calves that were only grazed on bahiagrass pastures. These findings were similar to those recorded in this study.

The significant treatment*month interaction ($P = 0.0001$) was due to significant increases in cattle daily weight gain over time for all cattle (Table 19). The cattle that were fed Super 12 concentrate and allowed to graze reached the target weight of 453 ± 22 kg approximately three months faster than cattle fed B-80 and allowed to graze, or cattle that were allowed to graze only. After month seven, cattle that had reached the target weight were weighed and transported to a local meat processing plant for harvesting. A total of 10 cattle (9 from the Super 12 treatment, and 1 from the grazers treatment) were harvested. The remaining cattle (i.e. 20 animals) were placed on Super 12 concentrate and allowed to graze until the target weight was reached (Table 20). After three months on Super 12 feed, the cattle that were initially given the B-80 and allowed to graze, and the cattle that were initially allowed to graze only had similar ($P > 0.05$) average daily gain. Both groups had significantly lower ($P < 0.05$) average daily gain when compared to cattle that were fed Super 12 initially (Table 20). The cattle that were initially fed diets of B-80 and allowed to graze, and cattle that were allowed to graze only reached the target weight within an additional three months after being fed Super 12 concentrate.

Table 20. Average daily weight gain values of Brangus steers that were initially fed Super 12, or B-80 and allowed to graze, or allowed to graze only and then placed onto Super 12 concentrate: Experiment Two.

Treatment	Average Daily Gain (kg)			
	Months			
	8[a]	9	10	Final Weight (kg)[b]
Super 12[c]	1.0[xf]	1.0[xf]	0.9[xf]	489.9[x]
Super 12(B-80)[d]	0.6[yf]	0.6[yf]	0.6[yf]	447.2[y]
Super 12 (Grazers)[e]	0.6[yf]	0.6[yf]	0.6[yf]	432.9[y]

[a]first set of 10 steers slaughtered and remaining 20 animals placed on Super 12 concentrate
[b] final weight (kg)
[c]Super 12 consisted of 1 remaining steer given Super 12 concentrate and allowed to graze on bahiagrass
[d]Super 12 (B-80) consisted of 10 steers given B-80 concentrate with lasalocid" and allowed to graze on bahiagrass until month 8 at which time they were removed from B-80 and given Super 12 and allowed to graze
[e]Super 12 (Grazers) consisted of 9 steers allowed to graze on bahiagrass only until month 8 at which time they were given Super 12 concentrate and allowed to graze
[f]means in the same row with different superscripts differ significantly ($P \leq 0.05$).
[x-y]means in the same column with different superscripts differ significantly ($P \leq 0.05$).

Microbiology of Fecal Samples

There was a significant treatment*month interaction ($P = 0.0008$) for total aerobic bacteria. The significant interaction was due to decreases in aerobic bacteria after the first month, until month 4, then an increase during month 5. During months 0, 3, and 5, all cattle had similar ($P > 0.05$) aerobic bacteria counts. After one month, cattle that were fed Super 12 and allowed to graze, and cattle that were fed B-80 and allowed to graze were similar ($P > 0.05$) for aerobic bacteria, but had significantly higher ($P < 0.05$) aerobic bacteria counts when compared to cattle that were allowed to graze only (Table 21). After two months, cattle that were fed Super 12 had significantly higher ($P < 0.05$)

aerobic bacteria counts when compared to the cattle that were fed B-80 and the cattle that were allowed to graze only (Table 21). The cattle that were fed B-80 and the cattle that

Table 21. Mean total aerobic bacteria counts, of steer fecal samples. Steers were given two different commercially available feeds and allowed to graze on bahiagrass or allowed to graze only for Experiment Two.

	$\log_{10}$ CFU/g								
	Month								
Treatment	0[a]	1	2	3	4	5	6	7	Overall mean
Super 12[b]	7.1^{xfg}	8.1^{xe}	7.5^{xf}	6.3^{xh}	6.1^{yh}	6.8^{xg}	6.2^{xh}	7.1^{xfg}	6.9^{x}
B-80[c]	7.1^{xf}	7.8^{xye}	7.0^{yf}	6.6^{xfg}	6.3^{xygh}	6.7^{xfg}	6.0^{xh}	6.9^{xyf}	6.8^{x}
Grazers[d]	6.9^{xef}	7.4^{ye}	6.8^{yef}	6.6^{xf}	6.5^{xf}	6.7^{xf}	5.0^{yg}	6.7^{yef}	6.6^{y}
mean	7.1^{f}	7.7^{e}	7.1^{f}	6.5^{h}	6.3^{b}	6.7^{gh}	5.7^{i}	6.9^{fg}	

[a]first month of steers on respective diets (November).
[b]Super 12 consisted of 10 steers given Super 12 concentrate and allowed to graze on bahiagrass.
[c]B-80 consisted of 10 steers given B-80 concentrate with "lasalocid" and allowed to graze on bahiagrass.
[d]Grazers consisted of 10 steers allowed to graze on bahiagrass only.
[e-i]means in the same row with different superscripts differ significantly ($P \leq 0.05$).
[x-y]means in the same column with different superscripts differ significantly ($P \leq 0.05$).

were allowed to graze only had similar ($P > 0.05$) aerobic bacteria counts after two months. After four months, the cattle that were allowed to graze only had significantly higher ($P < 0.05$) aerobic bacteria counts when compared to the cattle that were fed Super 12 (Table 21). The cattle that were allowed to graze only had similar ($P > 0.05$) aerobic bacteria counts compared to cattle that were fed B-80 during this time. After six months, all cattle experienced a significant ($P < 0.05$) decline in aerobic bacteria counts. However, cattle that were fed Super 12 and cattle that were fed B-80 had significantly higher ($P < 0.05$) aerobic bacteria counts when compared to cattle that were allowed to

graze only (Table 21). Overall, aerobic bacteria for cattle fed Super 12 and allowed to graze, and cattle fed B-80 and allowed to graze were similar ($P > 0.05$) but were significantly higher ($P < 0.05$) than cattle that were allowed to graze only (Table 21).

Generic *E. coli*, *E. coli* O157:H7, and Fecal coliforms

The data revealed no significant interaction ($P = 0.2209$) for generic *E. coli*. In general, generic *E. coli* decreased as time increased until month 7 when it increased. The highest level of generic *E. coli* was observed during months 1 and 7 (Table 22). Overall, cattle that were fed the Super 12 concentrate had a significantly higher ($P < 0.05$) amount of generic *E. coli* than did the cattle that were fed B-80 or the cattle that were allowed to graze only. In months 0, 4, and 7, cattle in all three treatments were similar ($P > 0.05$) for generic *E. coli* (Table 22). During months 1, 2, 3, and 6, the Super 12 concentrate group had significantly higher ($P > 0.05$) generic *E. coli* counts when compared to the grazers (Table 22). The cattle that were fed the B-80 medicated concentrate were similar ($P > 0.05$) to the cattle that received the Super 12 concentrate during months 1 and 3 (Table 22). Several studies have reported peak fecal shedding of *E. coli* O157:H7 during the spring and summer months (Wells et al., 1991; Hancock et al., 1997; Mechie et al., 1997). A possible reason for differences observed in peak fecal shedding of *E. coli* O157:H7 during the spring and summer months could be due to the fact that warmer temperatures contribute to the growth and spread of *E. coli* O157:H7 in the animal environment (Buchko et al., 2000). In the current study, no *E. coli O157:H7* nor *Salmonella* spp. was detected in any of the fecal samples collected from the steers.

There was a significant treatment*month interaction ($P = 0.0027$) for fecal coliforms. There was a general decrease in fecal coliforms over time until month 7 when

an increase was observed. Initially, and during months 3 and 4, cattle in all treatments had similar ($P > 0.05$) fecal coliform counts (Table 23).

Table 22. Mean generic *Escherichia coli* counts, of steer fecal samples. Steers were given two different commercially available feeds and allowed to graze on bahiagrass or allowed to graze only for Experiment Two.

	$\log_{10}$ CFU/g								
	Month								
Treatment	0[a]	1	2	3	4	5	6	7	Overall mean
Super 12[b]	6.0^{xf}	7.0^{xe}	7.0^{xe}	6.5^{xef}	5.6^{xfg}	5.7^{xfg}	5.0^{xg}	6.5^{xef}	6.1^{x}
B-80[c]	6.2^{xef}	6.9^{xe}	6.4^{yef}	6.3^{xyef}	5.3^{xfg}	4.8^{xg}	3.0^{yh}	6.2^{xef}	5.7^{y}
Grazers[d]	6.2^{xe}	6.2^{ye}	6.3^{ye}	6.0^{yef}	4.9^{xfg}	4.0^{xgh}	3.0^{yh}	6.0^{xef}	5.3^{y}
mean	6.1^{f}	6.7^{e}	6.6^{ef}	6.2^{ef}	5.3^{g}	4.8^{g}	3.7^{h}	6.2^{ef}	

[a]first month of steers on respective diets (November).
[b]Super 12 consisted of 10 steers given Super 12 concentrate and allowed to graze on bahiagrass.
[c]B-80 consisted of 10 steers given B-80 concentrate with "lasalocid" and allowed to graze on bahiagrass.
[d]Grazers consisted of 10 steers allowed to graze on bahiagrass only.
[e-h]means in the same row with different superscripts differ significantly ($P \leq 0.05$).
[x-y]means in the same column with different superscripts differ significantly ($P \leq 0.05$).

During months 1, 2, 5, and 6, cattle that were fed Super 12 had significantly higher ($P < 0.05$) fecal coliform counts when compared to cattle that were fed B-80 and cattle that were allowed to graze only (Table 23). During month 7, cattle fed Super 12 and B-80 had significantly higher fecal coliform counts when compared to cattle allowed to graze only (Table 23). Overall, cattle that were fed Super 12 had significantly higher ($P < 0.05$) fecal coliform counts compared to the cattle that were fed B-80 and the cattle that were allowed to graze only (Table 23). Overall the cattle that were fed B-80 and the cattle that were allowed to graze only had similar ($P > 0.05$) fecal coliform counts.

Table 23. Mean Fecal coliforms counts, of steer fecal samples. Steers were given two different commercially available feeds and allowed to graze on bahiagrass or allowed to graze only for Experiment Two.

	Log_{10} CFU/g								
	Month								
Treatment	0[a]	1	2	3	4	5	6	7	Overall mean
Super 12[b]	6.2^{xghi}	7.4^{xe}	7.5^{xe}	6.6^{xfg}	5.9^{xi}	6.5^{xfgh}	6.1^{xhi}	6.9^{xf}	6.6^{x}
B-80[c]	6.3^{xe}	6.8^{ye}	6.8^{ye}	6.4^{xe}	5.2^{xf}	4.8^{yf}	3.5^{yg}	6.5^{xye}	5.8^{y}
Grazers[d]	6.2^{xef}	6.2^{yef}	6.5^{ye}	6.1^{xef}	5.1^{xfg}	4.4^{yg}	3.1^{yh}	5.7^{yef}	5.4^{y}
mean	6.2^{f}	6.8^{ef}	6.9^{e}	6.3^{f}	5.4^{g}	5.2^{g}	4.2^{h}	6.4^{ef}	

[a]first month of steers on respective diets (November).
[b]Super 12 consisted of 10 steers given Super 12 concentrate and allowed to graze on bahiagrass.
[c]B-80 consisted of 10 steers given B-80 concentrate with "lasalocid" and allowed to graze on bahiagrass.
[d]Grazers consisted of 10 steers allowed to graze on bahiagrass only.
[e-i]means in the same column with different superscripts differ significantly ($P \leq 0.05$).
[x-y]means in the same row with different superscripts differ significantly ($P \leq 0.05$).

Microbiology of Bahiagrass

The mean total aerobic bacteria counts for the bahiagrass samples were similar ($P > 0.05$) (Table 24). The grass samples that were collected from the plots where cattle fed Super 12 were allowed to graze had significantly higher ($P < 0.05$) generic *E. coli* counts when compared to grass samples taken from plots where cattle fed B-80 and the grazers were allowed to graze (Table 24). There was a significant ($P < 0.05$) decrease in *E. coli* counts from November (month 0) to June (month 8) observed for all treatments. The grass samples that were taken from the plots of the B-80 fed cattle, and the graze only cattle had similar ($P > 0.05$) generic *E. coli* counts. The fecal coliform counts for all

bahiagrass samples were similar (P > 0.05) (Table 24). No *E. coli* O157:H7 was detected in any of the bahiagrass samples.

Table 24. Mean total aerobic bacteria counts, *Escherichia coli*, and Fecal coliform counts of bahiagrass that was grazed by all three groups of steers only for Experiment Two.

	Total aerobic bacteria (log_{10} CFU/g)			*E. coli* (log_{10} CFU/g)			Fecal coliforms (log_{10} CFU/g)		
	Month								
Treatment	0	8	Mean	0	8	Mean	0	8	Mean
Super 12[a]	6.0^{xd}	6.3^{xd}	6.2^{x}	5.4^{xd}	3.4^{xe}	4.1^{x}	4.5^{xd}	4.3^{xd}	4.4^{x}
B-80[b]	5.8^{xd}	6.5^{xd}	6.2^{x}	4.5^{xd}	2.6^{xe}	3.6^{y}	4.6^{xd}	4.0^{xd}	4.3^{x}
Grazers[c]	6.1^{xd}	6.0^{xd}	6.1^{x}	5.5^{xd}	2.0^{xe}	3.6^{y}	4.5^{xd}	4.0^{xd}	4.3^{x}

[a]Super 12 consisted of 10 steers given Super 12 concentrate and allowed to graze on bahiagrass.
[b]B-80 consisted of 10 steers given B-80 concentrate with "lasalocid" and allowed to graze on bahiagrass.
[c]Grazers consisted of 10 steers allowed to graze on bahiagrass only.
[d-e]means in the same row with different superscripts differ significantly (P ≤ 0.05).
[x-y]means in the same column with different superscripts differ significantly (P ≤ 0.05).

Animal Drinking Water

The total aerobic bacteria counts, fecal coliforms, and generic *E. coli* for animal drinking water samples were similar (P > 0.05) for all treatments (Table 25). No *E. coli* O157:H7 was detected in any of the drinking water samples. Buchko et al. (2000) isolated *E. coli* O157:H7 in water and water trough biofilm swabs and suggested that contaminated water troughs may be a potential site where *E. coli* O157:H7 is maintained and from which it may be spread among animals. Shere et al. (1998) determined that oral contamination as opposed to fecal contamination resulted in the dissemination of *E. coli* O157:H7 through animal drinking water.

Table 25. Mean total aerobic bacterial counts, *Escherichia coli*, and Fecal coliform counts of the animal drinking water of steers given two different commercially available feeds and allowed to graze on bahiagrass or allowed to graze only for Experiment Two.

	Total aerobic bacteria (log_{10} CFU/ml)			*E. coli* (log_{10} CFU/ml)			Fecal coliforms (log_{10} CFU/ml)		
	Month								
Treatment	0	8	Mean	0	8	Mean	0	8	Mean
Super 12[a]	2.8^{xd}	3.5^{xd}	3.1^{x}	1.5^{xd}	1.0^{xd}	1.3^{x}	2.5^{xd}	1.5^{xd}	2.0^{x}
B-80[b]	2.5^{xd}	3.5^{xd}	2.8^{x}	1.2^{xd}	1.2^{xd}	1.2^{x}	1.8^{xd}	1.5^{xd}	1.7^{x}
Grazers[c]	2.7^{xd}	3.5^{xd}	3.0^{x}	1.4^{xd}	1.6^{xd}	1.5^{x}	2.5^{xd}	1.6^{xd}	2.1^{x}

[a]Super 12 consisted of 10 steers given Super 12 concentrate and allowed to graze on bahiagrass.
[b]B-80 consisted of 10 steers given B-80 concentrate with "lasalocid" and allowed to graze on bahiagrass.
[c]Grazers consisted of 10 steers allowed to graze on bahiagrass only.
[d-e]means in the same row with different superscripts differ significantly ($P \leq 0.05$).
[x-y]means in the same column with different superscripts differ significantly ($P \leq 0.05$).

Animal Feed

The total aerobic bacteria counts for the Super 12 feed was significantly higher ($P < 0.05$) when compared to the B-80 medicated feed. There was a significantly lower ($P < 0.05$) amount of total aerobic bacteria detected in the B-80 feed samples from November (month 0) and June (month 8). Total aerobic bacteria detected in month 0 and month 8 for Super 12 concentrate feed was similar ($P > 0.05$). No *E. coli*, fecal coliforms, and *E. coli* O157:H7 were detected in either feed for months 0 and 8 (Table 26).

Parasites

No significant treatment*month interaction ($P = 0.5113$) was revealed for coccidia isolated from the fecal samples. The cattle in all treatments had similar ($P > 0.05$) eggs per gram of coccidia isolated from their feces when compared to each other (Table 27).

In the current study no advantage in reduction of coccidia eggs by feeding B-80 medicated concentrate versus Super 12 concentrate, or allowing cattle to graze only was observed.

Table 26. Mean total aerobic bacterial counts, *E. coli*, and fecal coliforms of the two commercially available animal feeds given to the steers only for Experiment Two.

	(log10 CFU/g)		
	Month		
Feed	0	8	Mean
F-R-M Super 12[a]	4.6^{xc}	4.3^{xc}	4.4^{x}
B-80 Medicated[b]	5.6^{xc}	0.0^{yd}	2.8^{y}

[a]Super 12 concentrate fed to 10 animals in addition to grazing on bahiagrass.
[b]B-80 concentrate containing lasalocid and fed to 10 animals in addition to grazing on bahiagrass.
[c-d]means in the same row with different superscripts differ significantly ($P \leq 0.05$).
[x-y]means in the same column with different superscripts differ significantly ($P \leq 0.05$).

Coccidiosis is generally associated with young animals because their immune system has not developed the ability to combat heavy infections. These infections most commonly occur when animals are closely confined, particularly under conditions of poor sanitation and ventilation. They are less common in grazing animals, although they can occur in warm, moist conditions (Tritschler, 2003). Diet regimen had no effect on the level of the *Haemonchus, Moniezia, or Nematodirus* eggs isolated from the three treatment groups (Table 28).

Bahiagrass Samples

Moisture, ash, fat, protein, and pH of the grass samples were similar ($P > 0.05$) for all plots of grass where the animals grazed (Table 29).

Table 27. Mean coccidia parasitic eggs isolated from feces of steers given two different commercially available feeds and allowed to graze on bahiagrass or allowed to graze only for Experiment Two.

Treatment	Coccidia Parasite Eggs (EPG)								
	Month								
	0[a]	1	2	3	4	5	6	7	Overall mean
Super 12[b]	0.2^{xe}	0.9^{xe}	0.1^{xe}	0.1^{xe}	1.0^{xe}	1.2^{xe}	0.2^{xe}	3.6^{xf}	0.9^{x}
B-80[c]	0.5^{xe}	0.8^{xef}	1.8^{xef}	2.6^{xef}	2.8^{xef}	1.5^{xef}	0.5^{xe}	3.2^{xf}	1.7^{x}
Grazers[d]	0.6^{xe}	1.3^{xef}	2.9^{xef}	2.3^{xef}	5.2^{xf}	3.6^{xef}	0.2^{xe}	3.0^{xef}	2.4^{x}

[a]first month of steers on respective diets.
[b]Super 12 consisted of 10 steers given Super 12 concentrate and allowed to graze on bahiagrass.
[c]B-80 consisted of 10 steers given B-80 concentrate with "lasalocid" and allowed to graze on bahiagrass.
[d]Grazers consisted of 10 steers allowed to graze on bahiagrass only.
[e-f]means in the same row with different superscripts differ significantly ($P \leq 0.05$).
[x]means in the column with different superscripts differ significantly ($P \leq 0.05$).

Table 28. Mean parasitic eggs, isolated from feces of steers given two different commercially available feeds and allowed to graze on bahiagrass or allowed to graze only for Experiment Two.

Treatment	*Moniezia* (EPG)	*Haemonchus* (EPG)	*Nematodirus* (EPG)
Super 12[a]	0.0^{x}	0.5^{x}	1.3^{x}
B-80[b]	0.5^{x}	0.3^{x}	0.3^{x}
Grazers[c]	0.0^{x}	2.5^{x}	0.3^{x}

[a]Super 12 consisted of 10 steers given Super 12 concentrate and allowed to graze on bahiagrass.
[b]B-80 consisted of 10 steers given B-80 concentrate with "lasalocid" and allowed to graze on bahiagrass.
[c]Grazers consisted of 10 steers allowed to graze on bahiagrass only.
[x]means in the same column with different superscripts differ significantly ($P \leq 0.05$).

The NDF and ADF percentages of all grass samples were similar ($P > 0.05$) for all plots of grass where animals grazed. Similar to bahiagrass protein values in this study,

Sollenberger et al. (1989) reported a bahiagrass protein concentration of 11.6%. Davis and Kunkle (2003) reported a 13.3% protein concentration for bahiagrass. Neutral

Table 29. Mean proximate analysis values and pH for bahiagrass samples collected from pastures for Experiment Two.

	Bahiagrass					
Treatment	Super 12[a]		B-80[b]		Grazers[c]	
	Month 0[e]	Month 8[f]	Month 0	Month 8	Month 0	Month 8
Moisture, %	51.3[d]	58.7[d]	58.6[d]	54.9[d]	67.8[d]	61.9[d]
Ash, %	5.6[d]	5.6[d]	5.5[d]	5.7[d]	5.9[d]	6.0[d]
Fat, %	2.6[d]	1.5[d]	2.8[d]	1.6[d]	2.2[d]	1.7[d]
Protein, %	9.5[d]	13.8[d]	10.2[d]	13.2[d]	10.1[d]	14.1[d]
NDF, %	70.5[d]	69.3[d]	70.4[d]	69.3[d]	70.6[d]	69.7[d]
ADF, %	29.7[d]	30.9[d]	29.9[d]	31.3[d]	29.9[d]	30.6[d]
pH	6.6[d]	6.8[d]	6.5[d]	6.6[d]	6.7[d]	6.7[d]

[a]Super 12 consisted of 10 steers given Super 12 concentrate and allowed to graze on bahiagrass.
[b]B-80 consisted of 10 steers given B-80 concentrate with "lasalocid" and allowed to graze on bahiagrass.
[c]Grazers consisted of 10 steers allowed to graze on bahiagrass only.
[d]means in the same row with different superscripts differ significantly ($P \leq 0.05$).
[e]November 2003
[f]June 2004

detergent fiber (NDF) is an estimate of the plant's cell wall content. It represents the total plant fiber or cell wall including hemicellulose, cellulose and lignin. Acid detergent fiber (ADF) is the percentage of highly indigestible or slowly digestible fiber in a forage. It contains cellulose as well as silica and lignin which are associated with low digestibility (Belyea et al., 2005). Neutral detergent fiber and ADF values for bahiagrass have been found to range from 68-75% and 44% on a dry matter basis, respectively (Belya et al., 2005; Kalmbacher and Wade, 2003). Preston, 2006 reported NDF and ADF values of

72% and 41%, respectively for bahiagrass. These findings were similar to those recorded in this study.

Cattle Blood Samples

Significantly higher ($P < 0.05$) amounts of chloride were detected in cattle that were fed Super 12 and B-80 concentrates when compared to cattle that were allowed to graze only (Table 30). The concentration of chloride was similar ($P > 0.05$) for cattle that were fed Super 12 and B-80 concentrates. Although there was a significantly lower concentration of chloride detected in the blood of the animals that were allowed to graze only, all cattle were within the expected range of 101-113 mEq/L.

Table 30. Mean blood for chloride, sodium, potassium and phosphorous for steers given two different commercially available feeds and allowed to graze on bahiagrass or allowed to graze only for Experiment Two.

Treatment	Chloride (mEq/L)	Sodium (mEq/L)	Phosphorous (mg/dL)	Potassium (mEq/L)
Super 12[a]	104.2^{x}	144.1^{x}	8.0^{x}	4.9^{y}
B-80[b]	104.0^{x}	143.1^{xy}	7.5^{xy}	5.3^{x}
Grazers[c]	101.6^{y}	141.9^{y}	7.3^{y}	5.0^{xy}

[a]Super 12 consisted of 10 steers given Super 12 concentrate and allowed to graze on bahiagrass.
[b]B-80 consisted of 10 steers given B-80 concentrate with "lasalocid" and allowed to graze on bahiagrass.
[c]Grazers consisted of 10 steers allowed to graze on bahiagrass only.
$^{x-y}$means in the same column with different superscripts differ significantly ($P \leq 0.05$).

Significantly higher ($P < 0.05$) amounts of sodium and phosphorous were detected in the blood of cattle fed Super 12 when compared to cattle that were allowed to graze only. Cattle that were allowed to graze only were similar ($P > 0.05$) in sodium and phosphorous when compared to cattle that were fed B-80 (Table 30). All of the measured values of sodium and phosphorous in all cattle, were within the expected range of 140-

148 mEq/L and 4.5-8.5 mg/dL for sodium and phosphorous, respectively. A significantly higher ($P < 0.05$) amount of potassium was detected in the blood of the cattle that were fed B-80 concentrate when compared to cattle that were fed Super 12 concentrate (Table 30).

Potassium levels for cattle that were allowed to graze only were similar ($P > 0.05$) to cattle that were fed B-80 and Super 12 concentrates. Although there was a significantly higher amount of potassium detected in the cattle that were fed B-80, the level of potassium for all cattle was within the expected range of 3.6-5.6 mEq/L.

Carcass

The cattle that were fed Super 12 concentrate had significantly higher ($P < 0.05$) carcass weights when compared to cattle that were fed B-80 and the cattle that were allowed to graze only (Table 31). The cattle that were fed B-80 and the cattle that were allowed to graze only had similar ($P > 0.05$) carcass weight. Even though the cattle that were fed Super 12 had a higher carcass weight, the dressing percentage was similar ($P > 0.05$) for all treatments (Table 31). The subjective carcass color of the lean, firmness of the lean, and texture of the lean were similar ($P > 0.05$) for all three groups of cattle (Table 31). The cattle that were fed the Super 12 concentrate were found to have a light cherry red lean color, and a slightly coarse lean texture. Meanwhile, cattle that were fed B-80 and cattle that were allowed to graze only were found to have a slightly light cherry red lean color, and a moderately fine lean texture. All steers in the three treatment groups had moderately firm lean. Cattle that were fed Super 12 concentrate had significantly higher ($P < 0.05$) fat over the eye thickness compared to the cattle that were fed the B-80 and the cattle that were allowed to graze only (Table 31). Cattle that were fed B-80 and

cattle that were allowed to graze only had similar ($P > 0.05$) fat thickness. Cattle fed Super 12 had significantly higher ($P < 0.05$) ribeye area when compared to cattle that were allowed to graze only. Cattle fed B-80 had similar ($P < 0.05$) ribeye area when compared to cattle fed Super 12 and cattle allowed to graze only (Table 31). Marbling scores and lean maturity of all cattle were similar ($P > 0.05$) (Table 31). Cattle that were

Table 31. Carcass characteristics and standard error of means for steers that were given two different commercially available feeds and allowed to graze on bahiagrass or allowed to graze only for Experiment Two.

Trait	Super 12[a]	B-80[b]	Grazers[c]	SEM
Hot carcass weight, kg	255.3[i]	232.3[j]	229.8[j]	16.56
Dressing percent, %	53.9[i]	52.0[i]	52.5[i]	-
Lean color[d]	3.0[i]	3.9[i]	4.1[i]	0.35
Lean firmness[e]	3.0[i]	2.9[i]	2.9[i]	0.15
Lean texture[f]	4.0[i]	3.4[i]	3.4[i]	0.23
Fat thickness, cm	2.4[i]	1.4[j]	1.4[j]	0.04
Ribeye area, cm^2	69.7[i]	66.8[ij]	58.8[j]	0.53
Marbling score[g]	Sl^{0i}	T^{90i}	T^{90i}	24.28
Lean maturity[h]	A[i]	A[i]	A[i]	3.89

[a]Super 12 consisted of 10 steers given Super 12 concentrate and allowed to graze on bahiagrass.
[b]B-80 consisted of 10 steers given B-80 concentrate with "lasalocid" and allowed to graze on bahiagrass.
[c]Grazers consisted of 10 steers allowed to graze on bahiagrass only.
[d]1= dark pink, 2= very light cherry red, 3= light cherry red, 4= slightly light cherry red, 5= cherry red, 6= moderately dark red, 7= dark red, 8= very dark red.
[e]1= very firm, 2= firm, 3= moderately firm, 4= slightly soft, 5= soft, 6= very soft, 7= extremely soft.
[f]1= very fine, 2= fine, 3= moderately fine, 4= slightly coarse, 5= coarse, 6= very coarse, 7= extremely coarse.
[g]Sl= Slight, T= Trace
[h]A= approximate live age of 9-30 months.
[i-j]means in the same row with different superscripts differ significantly ($P \leq 0.05$).

fed Super 12 concentrate had slight marbling scores. Cattle that were fed B-80 and cattle that were allowed to graze only, had a trace of marbling (Table 31). All cattle were scored "A" maturity.

Numerous researchers (Aberle et al., 1981; Bowling et al., 1978; Larick et al., 1987; Schroeder et al., 1980) have reported that as the period of time that cattle receive high energy finishing diets is increased, there is an improvement in marbling scores, quality grade and increased hot carcass weight. French et al. (2001) reported that animals fed only grass (perennial ryegrass pasture) had lower carcass weights when compared to animals fed a mixture of grass plus concentrates (barley, beet pulp, maize gluten, soybean meal) and animals fed concentrates only.

Objective Color Analysis

Feeding regimen did not affect brightness (L*), redness (a*) and yellowness (b*) values of steaks (Table 32). The steaks from all cattle in the three treatment groups weresimilar ($P > 0.05$) for L*, a*, and b* values. Schroeder et al. (1980) demonstrated that carcasses from an all forage diet (consisting of crested wheatgrass, native range, and forage sorghum) had darker ribeye color and lower consumer acceptability when compared to grain fed beef carcasses. Schroeder et al. (1980) reported that inclusion of grain into the diet, improved lean color and retail acceptability. O'Sullivan et al. (2003) reported no difference in a* values for steaks from forage and concentrate fed steers. Results from the current study agreed with those of French et al. (2001) who reported that pre-slaughter diet of grass , grass plus concentrates, or concentrates alone, had no effect on Hunter L* a* and b* values.

Table 32. Mean objective color values of steaks cut from the short loin portion of steers given two different commercially available feeds and allowed to graze on bahiagrass or allowed to graze only for Experiment Two.

Treatment	L	a	b
Super 12[a]	43.4[x]	23.4[x]	9.0[x]
B-80[b]	41.1[x]	23.4[x]	8.0[x]
Grazers[c]	40.2[x]	23.4[x]	7.9[x]

[a]Super 12 consisted of 10 steers given Super 12 concentrate and allowed to graze on bahiagrass.
[b]B-80 consisted of 10 steers given B-80 concentrate with "lasalocid" and allowed to graze on bahiagrass.
[c]Grazers consisted of 10 steers allowed to graze on bahiagrass only.
[x]means in the same column with different superscripts differ significantly ($P \leq 0.05$).

pH

Feeding regimen had no effect on the pH of the steaks (Table 33). As was discussed previously, once the pH of meat nears the isoelectric point of muscle proteins (5.4) the proteins lose their ability to bind water. As the pH of meat increases above the 5.4 threshold, the water holding capacity of the proteins increase. Muir et al. (1998) reported that the pH of steaks from both pasture fed steers and grain fed steers was acceptable (i.e., less than pH 5.8) but that steaks from grain fed steers tended to have an overall lower pH (5.76 and 5.60 for pasture- and grain-fed steers respectively).

Thaw loss/Cooking loss

No significant interaction ($P = 0.8718$) was found for thaw loss nor cooking loss ($P = 0.9020$). Steaks from all cattle in the three treatment groups were similar ($P > 0.05$) for percent thaw loss and cooking loss (Table 34). The steaks from the cattle that were fed Super 12 concentrate had at least 2.0% higher thaw loss when compared to cattle fed B-80 and cattle allowed to graze only.

Table 33. Mean pH values of steaks cut from the short loin portion steers given two different commercially available feeds and allowed to graze on bahiagrass or allowed to graze only for Experiment Two.

Treatment	pH
Super 12[a]	5.6[x]
B-80[b]	5.7[x]
Grazers[c]	5.7[x]

[a]Super 12 consisted of 10 steers given Super 12 concentrate and allowed to graze on bahiagrass.
[b]B-80 consisted of 10 steers given B-80 concentrate with "lasalocid" and allowed to graze on bahiagrass.
[c]Grazers consisted of 10 steers allowed to graze on bahiagrass only.
[x]means in the same column with different superscripts differ significantly ($P \leq 0.05$).

Table 34. Mean thaw loss and cooking loss for steaks cut from the short loin portion of steers given two different commercially available feeds and allowed to graze on bahiagrass or allowed to graze only for Experiment Two.

Treatment	Percent Thaw loss	SEM	Percent Cooking loss	SEM
Super 12[a]	4.9[x]	0.48	27.3[x]	0.61
B-80[b]	2.9[x]	0.48	27.4[x]	0.61
Grazers[c]	2.5[x]	0.48	27.7[x]	0.61

[a]Super 12 consisted of 10 steers given Super 12 concentrate and allowed to graze on bahiagrass.
[b]B-80 consisted of 10 steers given B-80 concentrate with "lasalocid" and allowed to graze on bahiagrass.
[c]Grazers consisted of 10 steers allowed to graze on bahiagrass only.
[d]means in the same column with different superscripts differ significantly ($P \leq 0.05$).

Sensory and Warner Bratzler Shear Analyses

No significant interaction was found for any of the sensory attributes that were examined by the trained sensory panel. All treatment groups had similar ($P > 0.05$) beef flavor, overall tenderness, connective tissue, and off-flavor scores (Table35). One reason for the similarity in steaks was possibly because cattle that were not ready for harvest

(i.e., had not reached the target weight) when the cattle initially fed Super 12 achieved the target weight, were removed from their respective feeds and placed on Super 12 until they reached their target weight which was an additional three months after the first group of cattle were harvested. Crouse et al. (1984) reported that steaks from grass-fed heifers were similar to those from grain-fed heifers in terms of tenderness, juiciness, and flavor. The panelists determined that the steaks from the cattle fed Super 12 and steaks from the cattle fed B-80 were significantly lower ($P < 0.05$) in juiciness when compared to steaks from the cattle that were allowed to graze only (Table 35).

Table 35. Mean trained sensory panel scores of steaks cut from the short loin portion steers given two different commercially available feeds and allowed to graze on bahiagrass or allowed to graze only for Experiment Two.

Treatment	Juiciness	Beef flavor	Tenderness	Connective tissue	Off-flavor
Super 12[a]	4.5[y]	5.4[x]	5.2[x]	6.4[x]	5.1[x]
B-80[b]	4.8[y]	5.4[x]	5.3[x]	6.1[x]	5.2[x]
Grazers[c]	5.3[x]	5.5[x]	5.3[x]	6.1[x]	5.4[x]

[a]Super 12 consisted of 10 steers given Super 12 concentrate and allowed to graze on bahiagrass.
[b]B-80 consisted of 10 steers given B-80 concentrate with "lasalocid" and allowed to graze on bahiagrass.
[c]Grazers consisted of 10 steers allowed to graze on bahiagrass only.
[x-y]means in the same column with different superscripts differ significantly ($P \leq 0.05$).

It was determined by the panelists that steaks from all cattle had a "slightly intense" beef flavor, a "moderately tender" overall tenderness, "trace amounts" of connective tissue and a "threshold or barely detected" off-flavor (Table 35). Steaks from cattle that were allowed to graze only were rated as slightly juicy by trained panelists. Steaks from the cattle that were fed B-80 and Super 12 were rated as being "slightly dry" (Table 35). Oltjen et al. (1971) and Young and Kauffman (1978) reported differences in juiciness

between forage- and grain-fed beef. In both studies, there were differences in carcass fatness, which paralleled the increasing juiciness scores. Muir et al. (1998) concluded that increased juiciness in beef from grain-fed cattle relative to grass-fed cattle was due to differences in carcass growth rate and/or fat cover. No adverse effect on Warner-Bratzler shear force (WBS) was revealed due to feeding regimen for any of the loin steaks.

Table 36. Mean Warner-Bratzler Shear force (WBS) values of steaks cut from the short loin portion steers given two different commercially available feeds and allowed to graze on bahiagrass or allowed to graze only for Experiment Two.

Treatment	Warner-Bratzler Shear Force (kg)
Super 12[a]	4.8[x]
B-80[b]	4.3[x]
Grazers[c]	4.5[x]

[a]Super 12 consisted of 10 steers given Super 12 concentrate and allowed to graze on bahiagrass.
[b]B-80 consisted of 10 steers given B-80 concentrate with "lasalocid" and allowed to graze on bahiagrass.
[c]Grazers consisted of 10 steers allowed to graze on bahiagrass only.
[x]means in the same column with different superscripts differ significantly ($P \leq 0.05$).

All loin steaks had similar ($P > 0.05$) WBS (Table 36). The WBS values ranged from 4.3 to 4.8 kg. Shackelford et al. (1991) published the first threshold relating Warner-Bratzler shear force values to consumer data. These researchers reported that WBS values less than 3.5 kg were considered "tender," 3.6 to 4.9 were considered "acceptable tenderness," and values greater than 5.0 "tough." Using this scale, all loin steaks in Experiment Two, would be rated "acceptable tenderness." The findings in this study for WBS were similar to those reported by French et al. (2001). French et al. (2001) reported no difference in WBS for steaks from animals fed perennial ryegrass

pasture alone, perennial ryegrass pasture plus concentrates (barley, beet pulp, maize gluten, soybean meal), or concentrates alone.

Cost Analysis for Experiment One

The cattle that were used in Experiment One were donated to the project and therefore, there was not an animal purchase cost associated with Experiment One. As a result, the costs for animals used in Experiment One are estimations based on Experiment Two animal purchase data. Experiment One used a total of 30 animals with an average weight of 345 kg (760 lbs). The animals could have been purchased for $1.81 per kilogram ($0.82 per pound). The price for animals used in Experiment One would have been approximately $624.45 per head of cattle. Therefore the total cost for animals would have been approximately $18,733.50 for 30 animals. The cost for labor/handling of cattle at the University of Florida facilities for this project was $1.50 per head per day. The total cost of labor and handling for Experiment One was $8,310.00 for six months. This amounts to a labor/handling cost of approximately $277 per animal. The cost of Super 12 was $13.00 per kilogram of feed. The cost of B-80 was $15.64 per kilogram of feed.

In this study, animals were grazed on 12 acres (4 acres per feeding regimen) of bahiagrass pastures. Bahiagrass establishment cost was estimated to be approximately $20/acre/year. This equates to $240/year for the 12 acres. Fertilizer (i.e., ammonium nitrate) was applied twice (two times per year) to a total of 12 acres (4 acres per feeding regimen) of bahiagrass. The cost of the fertilizer was $20 per acre. This equates to a total fertilizer cost of $480 (i.e., $20/acre x 12 acres x 2) for Experiment One. An additional labor cost was estimated at $10 per hour for 8 hours to apply and maintain the

pasture at two applications per year. The total estimated expense associated with the bahiagrass was $880.00 ($240/year for 12 acres + $480 fertilizer + $160 labor). This estimated cost is for the bahiagrass only and does not include water for irrigation, minerals needed, or incidental expenses.

Table 37. Commercial feed cost summary for Experiment One.

Feed	Days[d]	Feed/day[e] (kg)	Total feed[f] (kg)	Cost per kg	Total feed cost
[a]Super 12	136	11.1	1512.7	$13.00	$19,665.10
[b]B-80	136	2.3	308.7	$15.64	$4,828.07
Combined[c]	60	11.1	667.4	$13.00	$8,676.20
Total Cost					$33,169.37

[a]Super 12 concentrate fed to 10 animals in addition to grazing on bahiagrass
[b]B-80 concentrate containing lasalocid and fed to 10 animals in addition to grazing on bahiagrass
[c]remaining 16 animals (i.e., 4 from Super 12, 5 from B-80, and 7 from grazers group) placed on Super 12 until target weight range was reached
[d]no. of days on feed
[e]mean quantity of feed fed to cattle per day
[f]total feed for 136 & 60 additional days

Ten of the cattle were fed Super 12 and allowed to graze on bahiagrass ad libitum for a total of 136 days at which time the target weight of 453 ± 22 kg was reached. The total feed cost for cattle fed Super 12 during this time was $19,665.10 (Table 37). This amount equates to approximately $1966.51 per animal. A second group of ten cattle were fed B-80 and allowed to graze on bahiagrass ad libitum for a total of 136 days. The total feeding cost for cattle fed B-80 during this time period was $4828.07 (Table 37). This amount equates to approximately $482.81 per animal. When the first 14 cattle (i.e., 6 from Super 12, 5 from B-80, and 3 from grazing only) reached the target weight they were transported to a local processing facility and slaughtered. The remaining 16 (i.e., 4

fed Super 12 initially, 5 fed B-80 initially and 7 from grazing only) cattle were placed on Super 12 for 60 days until the target weight range was reached. The total feed cost during the 60 days was $8,676.20, which equate to $542.26 per animal.

Expenses for Super 12 Feeding Regimen for Experiment One

The total expense associated with the Super 12 feeding regimen (i.e., feeding cattle Super 12 concentrate and allowing them to graze on bahiagrass ad libitum) was $31,129.47 or $3,112.95 per animal. This cost is based on $6,232 for the cost of animals ($623.20/animal x 10 animals), $2,770 for the cost for labor/handling ($277/animal x 10 animals), $19,665.10 for Super 12 concentrate feed (Table 37), $2169.04 for additional Super 12 concentrate feed ($542.26/animal x 4 animals) and $293.33 for bahiagrass and fertilizer ($880/3). The selling price to break even for cattle fed Super 12 during Experiment One would be approximately $12.78 per kg carcass weight based on an average carcass weight of 243.7 kg for cattle fed Super 12.

Expenses for B-80 Feeding Regimen for Experiment One

The total expense associated with the B-80 feeding regimen (i.e., feeding cattle B-80 concentrate and allowing them to graze on bahiagrass ad libitum) was $16,833.70 or $1,683.37 per animal. This cost is based on $6,232 for the cost of animals ($623.20/animal x 10 animals), $2,770 for the cost for labor/handling ($277/animal x 10 animals), $4828.07 for B-80 concentrate feed (Table 37), $2710.30 for Super 12 concentrate feed ($542.06/animal x 5 animals) and $293.33 for bahiagrass and fertilizer ($880/3). The selling price to break even for cattle fed B-80 during Experiment One would be approximately $7.27 per kg carcass weight based on an average carcass weight of 231.7 kg for B-80 fed cattle.

Expenses for Grazing Only Regimen for Experiment One

The total expense associated with the grazing bahiagrass only regimen (i.e., allowing cattle to graze bahiagrass only ad libitum) was $13,089.75 or $1,308.98 per animal. This is based on $6,232 for the cost of animals ($623.20/animal x 10 animals), $2,770 for the cost for labor/handling ($277/animal x 10 animals), $3,794.42 for Super 12 concentrate feed ($542.06/animal x 7 animals) and $293.33 for bahiagrass and fertilizer ($880/3). The selling price to break even for cattle grazing bahiagrass only during Experiment One would be approximately $5.81 per kg carcass weight based on an average carcass weight of 225.3 for cattle allowed to graze only.

Cost Analysis for Experiment Two

The animals that were used in Experiment Two were purchased. Experiment Two used a total of 30 animals with an average weight of 225 kg (495 lbs). The animals in this experiment were purchased for $1.85 per kilogram ($0.84 per pound). This equates to approximately $416.25 per head of cattle. Therefore, the total cost for animals in Experiment Two was $12,487.50. The total cost for labor/handling of cattle in Experiment Two was $13,035.00 for ten months. This equates to a labor/handling cost of approximately $434.50 per animal. The cost of Super 12 was $13.00 per kilogram of feed. The cost of B-80 was $15.64 per kilogram of feed. As discussed previously, bahiagrass establishment cost was estimated to be approximately $20/acre/year. This equates to $240/year for 12 acres. The cost of the fertilizer was $20 per acre. This equates to a total fertilizer cost of $480 (i.e., $20/acre x 12 acres x 2) for Experiment Two. An additional labor cost was estimated at $10 per hour for 8 hours to apply and

maintain the pasture. The total estimated expenses associated with the bahiagrass was $880.00 ($240/year for 12 acres + $480 fertilizer + $160 labor).

Ten cattle were fed Super 12 for a total of 215 days at which time the target weight of 453 ± 22 kg was reached. The total feed cost for cattle fed Super 12 during this period was $31,086.90 (Table 38).

Table 38. Commercial feed cost summary for Experiment Two.

Feed	Days[d]	Feed/day[e] (kg)	Total feed[f] (kg)	Cost per kg	Total feed cost
[a]Super 12	215	11.1	2391.3	$13.00	$31,086.90
[b]B-80	215	2.3	488.1	$15.64	$7,633.88
Combined[c]	90	11.1	1001.1	$13.00	$13,014.30
Total Cost					$51,735.08

[a]Super 12 concentrate fed to 10 animals in addition to grazing on bahiagrass
[b]B-80 concentrate containing lasalocid and fed to 10 animals in addition to grazing on bahiagrass
[c]remaining 20 animals (i.e., 1 from Super 12, 10 from B-80, and 9 from grazers group) placed on Super 12 until target weight range was reached
[d]no. of days on feed
[e]mean quantity of feed fed to cattle per day
[f]total feed for 215 & 90 additional day

This equates to approximately $3108.69 per animal. A second group of cattle were fed B-80 for 215 days. The total feed cost for cattle fed B-80 was $7633.88 (Table 38). This amount equates to approximately $763.39 per animal. When the first ten cattle (i.e., 9 from Super 12 and 1 from grazing only) reached the target weight, they were transported to a local processing facility and slaughtered.. The remaining 20 animals (i.e., 1 fed Super 12 initially, 10 fed B-80 initially, and 9 from grazing only) were fed Super 12 for 90 additional days. The total feed cost during this period was $13014.30 (Table 38). This amount equates to approximately $650.72 per animal during this additional 90 days.

Expenses for Super 12 Feeding Regimen for Experiment Two

The total expense associated with the Super 12 feeding regimen (i.e., feeding cattle Super 12 and allowing them to graze bahiagrass ad libitum) was $40,538.45 or $4,053.85 per animal. This is based on $4,162.50 for the cost of animals ($416.25/animal x 10 animals), $4,345.00 for the cost for labor/handling ($434.50/animal x 10 animals), $31,086.90 for Super 12 concentrate feed (Table 38), $650.72 for additional Super 12 concentrate feed ($650.72/animal x 1 animal) and $293.33 for bahiagrass and fertilizer ($880/3). The selling price to break even for cattle fed Super 12 during Experiment Two would be approximately $15.88 per kg carcass weight based on an average carcass weight of 255.3 kg for cattle fed Super 12.

Expenses for B-80 Feeding Regimen for Experiment Two

The total expenses associated with the B-80 feeding regimen (i.e., feeding cattle B-80 and allowing them to graze bahiagrass ad libitum) was $22,941.91 or $2,294.19 per animal. This is based on $4,162.50 for the cost of animals ($416.25/animal x 10 animals), $4,345.00 for the cost for labor/handling ($434.50/animal x 10 animals), $7,633.88 for B-80 concentrate feed (Table 38), $6507.20 for Super 12 concentrate feed ($650.72/animal x 10 animals) and $293.33 for bahiagrass and fertilizer ($880/3). The selling price to break even for cattle fed B-80 during Experiment Two would be approximately $9.88 per kg carcass weight based on an average carcass weight of 232.3 kg for B-80 fed cattle.

Expenses for Grazing Only Regimen for Experiment One

The total expenses associated with the grazing bahiagrass only regimen (i.e., allowing cattle to graze bahiagrass only ad libitum) was $14,657.31 or $1,465.73 per

animal. This is based on $4,162.50 for the cost of animals ($416.25/animal x 10 animals), $4,345 for the cost for labor/handling ($434.50/animal x 10 animals), $5,856.48 for Super 12 concentrate feed ($650.72/animal x 9 animals) and $293.33 for bahiagrass and fertilizer ($880/3). The selling price to break even for cattle grazing bahiagrass only during Experiment Two would be approximately $6.38 per kg carcass weight based on an average carcass weight of 229.8 for cattle allowed to graze only.

Feed records indicated a possible reason for Super 12 fed cattle being more expensive per animal to produce was the fact that they were fed more Super 12 per animal than the B-80 fed cattle. According to feed records and manufacturer instructions, cattle fed B-80 were only given up to 2.3 kg per animal per day maximum due to the fact that B-80 is a medicated feed and contained lasalocid. This resulted in a greater total consumption of Super 12 compared to B-80. On average animals fed Super 12 were given up to 11.1 kg per animal per day.

SUMMARY AND CONCLUSIONS

This study examined the effects of three feeding regimens: Super 12, a non medicated concentrate, plus grazing on bahiagrass ad libitum; B-80, a medicated concentrate containing lasalocid, plus grazing bahiagrass ad libitum; and grazing on bahiagrass only ad libitum on performance (average daily weight gain and carcass characteristics), microbiology (the prevalence of *E. coli* O157:H7, generic *E. coli*, fecal coliforms, total aerobic bacteria, and parasites on the live animal, concentrates, and environmental samples such as grass and animal drinking water), objective, and sensory characteristics of Florida Brangus beef cattle. The proximate composition of the bahiagrass was also determined.

The nutrient content of Super 12 and B-80 were similar for protein, fat and crude fiber, according to the manufacturer's nutrition statement. All animals were given a mineral mix that was incorporated into their feeding regimen.

In general, the results from Experiment One were similar to the results in Experiment Two. In both experiments, cattle fed Super 12 concentrate reached the target weight of 453 kg faster than cattle fed B-80 or cattle allowed to graze only. Cattle fed B-80 and cattle that grazed on bahiagrass only reached the target weight after being placed on the Super 12 concentrate for an additional two (total of six months) and three months (total of 10 months) for Experiment One and Experiment Two, respectively. The final

live weights of the older animals (Experiment One) compared to the younger animals (Experiment Two) were similar although the younger animals took slightly longer to reach the target weight.

The three feeding regimens had no effect on total aerobic bacteria, generic *E. coli* or fecal coliforms in either experiment. The three regimens each showed a similar overall pattern of decreases, then increases across time for all three types of bacteria. The decreases in microbial counts were observed during months 1 and 3 in and increases in microbial counts were observed in months 2 and 4 for total aerobic bacteria during Experiment One. Generic *E. coli* counts increased over time during Experiment One. During Experiment Two, decreases were observed months 2, 4, and 6 for total aerobic bacteria and *E. coli*, and increases were observed in months 1, 5, and 7. No *E. coli* O157:H7 or *Salmonella* spp. was detected in either experiment. Lasalocid is an ionophore that can be used in animal feed as a coccidiostat. During Experiment One there were no significant differences ($P > 0.05$) in coccidia between cattle fed Super 12 and cattle fed B-80 which contained lasalocid. Both groups of cattle, however, did have a lower amount of coccidia than the cattle that were grazed on bahiagrass only. Therefore, according to the data in the current study, feeding beef cattle Super 12 without lasalocid was just as effective in reducing coccidia as feeding B-80 which contained lasalocid. During Experiment Two, coccidia counts were similar ($P > 0.05$) for the three groups. Diets in both experiments had no effect on the amount of *Haemonchus* or *Moniezia* eggs per gram isolated from the feces.

In both experiments, bacteria isolated from animal feed (Super 12 and B-80) were similar in log CFU/g. This finding led to the conclusion that animal feed used in this

study was not a major source of bacterial contamination. Also, in both experiments, bacteria isolated from animal drinking water were similar in log CFU/ml. This finding led to the conclusion that animal drinking supply was not a major source of bacterial contamination in this study.

Overall, in Experiment One and Experiment Two, regimens had no effect on total blood chemistry of the animals. All of the variables examined in the blood for all groups of cattle during both experiments were within their normal ranges.

During both experiments the carcass weight of the animals fed Super 12 was higher than the remaining two groups. It was evident in this study that feeding animals Super 12 in addition to bahiagrass resulted in an increased live weight and carcass weight in a shorter amount of time compared with feeding B-80 along with bahiagrass or bahiagrass only. The data revealed no significant differences ($P > 0.05$) among the three regimens for carcass subjective lean color, lean firmness, lean texture, and maturity during both experiments. Likewise, the regimens had no effect on objective color and pH of the resulting steaks in both experiments. The data demonstrated that feeding Florida Beef Brangus cattle Super 12 with bahiagrass, B-80 with bahiagrass or bahiagrass only had no adverse effects on the objective color nor pH of the resulting steaks.

In Experiment One, sensory panelists did not detect an effect due to diet for juiciness, beef flavor, or off-flavor. However, panelists did detect significant differences in overall tenderness and connective tissue. Panelists found that the steaks from the animals fed bahiagrass alone were more tender and had less connective tissue when compared with steaks from animals fed Super 12. In Experiment Two, panelists rated all steaks for all regimens similar ($P > 0.05$) for beef flavor, off-flavor, overall tenderness

and connective tissue. However, they did detect a significant difference ($P < 0.05$) in juiciness between the steaks from the animals fed the concentrates (both Super 12 and B-80) and the animals that grazed on bahiagrass only with the steaks from animals grazing on bahiagrass alone being more juicy. The Warner-Bratzler shear force results in Experiment One were similar ($P < 0.05$) for all steaks whereas, the panelists detected differences ($P < 0.05$) in tenderness between the steaks from the three regimens. In Experiment Two, the Warner-Bratzler shear force results were in agreement with the sensory panel data in that there were no differences ($P > 0.05$) detected in tenderness among the three groups of steaks. It was concluded that the feeding regimens, Super 12 with bahiagrass, B-80 with bahiagrass, or bahiagrass only, had no adverse effects on sensory characteristics of the resulting steaks.

Further research opportunities presented by this investigation are those involving 1) repeating this study using a greater number of animals and investigating feeding Super 12 with lasalocid added and grazing compared to feeding Super 12 without lasalocid and grazing to determine if the addition of lasalocid will result in increased weight gain, or a difference in carcass quality and sensory attributes. 2) Examining the same concentrates used in the current study but providing both of them in a pelleted form. 3) Repeating the study using the same concentrates but allowing each animal their own individual feeder instead of allowing all animals in a group to eat from the same feeding trough, and allowing animals to graze from separate pastures instead of all animals in a group grazing from the same pasture. 4) applying the same methods used in the current study along with more quicker and possibly more sensitive molecular techniques such as PCR and

DNA or RNA probes for identifying *E. coli* O157:H7 and *Salmonella* from fecal samples taken.

Implications

Small farms make up approximately 90% of the farms in the United States. The present study was conducted to develop a program that could be utilized by small livestock producers to enhance the value and safety of their products. Data in this study demonstrated that beef cattle fed Super 12 and allowed to graze on fertilized bahiagrass were ready for market in less time (two and three months faster) when compared to cattle that were only grazed on fertilized bahiagrass, and cattle that were given B-80 Medicated Pasture Supplement and grazed on fertilized bahiagrass. No pathogenic bacteria were detected in any of the cattle utilized in this study. The use of antibiotics in this study was limited to an as needed basis. Only one animal during the course of Experiment One required antibiotics. No animals during Experiment Two required antibiotics, however one animal did suffer from flounder. Carcass weights were higher for beef cattle fed Super 12 when compared to beef cattle fed only grass.

On a per animal basis, cattle grazing bahiagrass and supplemented with Super 12 are more expensive to produce when compared to cattle fed B-80 or cattle allowed to graze only. Cattle allowed to graze only were the least expensive to produce but required a longer time period to reach target weight. At the point when cattle that were fed Super 12 reached the target weight during Experiment One, cattle fed B-80 were at an average weight of 403 kg, which was 28 kg below the target weight range. Cattle that were allowed to graze only were at an average weight of 398 kg, which was 33 kg below the target weight range. At the point when cattle fed Super 12 reached the target weight

range during Experiment Two, cattle fed B-80 were at an average weight of 396 kg, which was 35 kg below the target weight range. Cattle that were allowed to graze only were at an average weight of 393 kg, which was 38 kg below the target weight range. The cattle fed B-80 and allowed to graze only in this study reached the target weight after being removed from their respective diets and placed on Super 12 for an additional 60 and 90 days in Experiments One and Two, respectively. In addition to reaching the target weight faster, Super 12 supported a greater average daily gain (i.e., 0.7 kg) compared to B-80 (i.e., 0.6 kg) and bahiagrass alone (i.e., 0.5 kg) in both experiments. The data suggested that beef cattle grazing bahiagrass and supplemented with Super 12 can produce steaks that would be acceptable in meat quality and palatability to consumers.

APPENDIX
MEAN WEIGHT OF BRANGUS STEERS DURING EXPERIMENT ONE AND TWO

Table 39. Mean weight of Brangus steers fed different commercially available feed concentrates, and allowed to graze on bahiagrass or allowed to graze only for four months: Experiment One.

	Weight (kg)				
	Months				
Treatment	0	1	2	3	4
Super 12[a]	345.4^{xi}	352.8^{xhi}	381.7^{xfgh}	411.9^{xef}	437.0^{xde}
B-80[b]	348.6^{xf}	368.5^{xef}	394.0^{xde}	405.8^{xd}	396.5^{yde}
Grazers[c]	342.4^{xg}	350.7^{xfg}	381.2^{xde}	382.5^{xde}	393.1^{yde}

[a]Super 12 consisted of 10 steers given F-R-M Super 12 concentrate and allowed to graze on bahiagrass.
[b]B-80 consisted of 10 steers given B-80 concentrate with "lasalocid" and allowed to graze on bahiagrass.
[c]Grazers consisted of 10 steers allowed to graze on bahiagrass only.
[d-i]means in the same row with different superscripts differ significantly ($P \leq 0.05$).
[x-y]means in the same column with different superscripts differ significantly ($P \leq 0.05$).

Table 40. Mean weight of Brangus steers that were initially fed Super 12, or B-80 and allowed to graze, or allowed to graze only and then placed onto Super 12 concentrate: Experiment One.

	Weight (kg)	
	Month	
Treatment	5	6
Super 12	456.6^{xe}	455.7^{xe}
Super 12 (B-80)[c]	403.4^{yef}	419.1^{xye}
Super 12 (Grazers)[d]	398.1^{yef}	408.8^{ye}

[a]remaining animals placed on Super 12 and allowed to graze.
[b]Super 12 consisted of 4 steers placed on Super 12 and allowed to graze on bahiagrass.
[c]Super 12 (B-80) consisted of 5 steers fed B-80 concentrate and allowed to graze on bahiagrass until month 5 at which time they were removed from B-80 and fed Super 12 and allowed to graze.
[d]Super 12 (Grazers) consisted of 7 steers allowed to graze on bahiagrass only until month 5 at which time they were fed Super 12 concentrate and allowed to graze.
[e-g]means in the same row with different superscripts differ significantly ($P \leq 0.05$).
[x-z]means in the same column with different superscripts differ significantly ($P \leq 0.05$).

Table 41. Mean weight of Brangus steers fed different commercially available feed concentrates, and allowed to graze on bahiagrass or allowed to graze only for ten months: Experiment Two.

	Weight (kg)						
	Months						
Treatment	Initial Weight[a]	0[b]	1	2	3	4	5
Super 12[c]	244.2^{xl}	242.1^{xl}	253.6^{xl}	307.2^{xk}	346.4^{xjk}	378.9^{xij}	407.3^{xhi}
B-80[d]	243.1^{xm}	239.0^{xm}	252.6^{xlm}	277.0^{ykl}	290.1^{yjk}	286.9^{yjk}	308.5^{yij}
Grazers[e]	252.7^{xk}	251.1^{xk}	268.2^{xjk}	268.6^{yjk}	258.3^{zjk}	270.6^{yjk}	302.1^{yij}

Treatment	Months				
	6	7	8[n]	9	10[o]
Super 12[c]	433.8^{xgh}	468.0^{xfg}	451.8^{xfg}	471.7^{xfg}	489.9^{xf}
B-80[d]	335.9^{yi}	363.1^{yh}	396.1^{xg}	419.8^{xfg}	447.2^{xf}
Grazers[e]	342.0^{yhi}	381.3^{ygh}	393.9^{xgh}	412.5^{xfg}	432.9^{xf}

[a]cattle initial weight (kg)
[b]project initial starting point
[c]Super 12 consisted of 10 steers given F-R-M Super 12 concentrate and allowed to graze on bahiagrass.
[d]B-80 consisted of 10 steers given B-80 concentrate with "lasolocid" and allowed to graze on bahiagrass.
[e]Grazers consisted of 10 steers allowed to graze on bahiagrass only.
[f-m]means in the same row with different superscripts differ significantly ($P \leq 0.05$).
[x-z]means in the same column with different superscripts differ significantly ($P \leq 0.05$).
[n]first set of 10 steers slaughtered and remaining 20 animals placed on Super 12 concentrate.
[o]cattle final live weight (kg)

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BIOGRAPHICAL SKETCH

Keawin Caron Sarjeant was born in Tallahassee, Florida, on May 8, 1977. He graduated high school from Florida A&M University Developmental Research School in 1995. He then attended Florida Agricultural and Mechanical University in Tallahassee, Florida, and graduated with a Bachelor of Science in May 1999. In the fall of 2000, Keawin began his pursuit of a Master of Science degree at the University of Florida in the Department of Animal Science under the supervision of Dr. Sally K. Williams. He was a recipient of the Alliance for Graduate Education and the Professoriate Fellowship. He received a Master of Science degree with a concentration in meat Science/food safety in May 2003.

In the spring of 2003, he began his studies for the Doctor of Philosophy degree in the College of Agricultural and Life Sciences under the supervision of Dr. Sally K. Williams. He was awarded a teaching and research assistantship in the Department of Animal Sciences. He was admitted to candidacy on November 21, 2004. Keawin earned his Doctor of Philosophy degree from the University of Florida in the spring of 2006.

Upon receiving his Doctor of Philosophy degree, Keawin plans to work in academia as an assistant professor of meat science/food safety/meat processing. This career choice should allow him to conduct research in meat science, do food safety consulting and teach both food microbiology and meat processing courses.

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

Sally K. Williams, Chair
Associate Professor of Animal Sciences

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

Dwain D. Johnson
Professor of Animal Sciences

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Adegbola Adesogan
Associate Professor of Animal Sciences

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Gary E. Rodrick
Professor of Food Science and Human Nutrition

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

Ray Mobley
Special Member

This dissertation was submitted to the Graduate Faculty of the College of Agricultural and Life Sciences and to the Graduate School and was accepted as partial fulfillment of the requirements for the degree of Doctor of Philosophy.

May 2006

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